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To

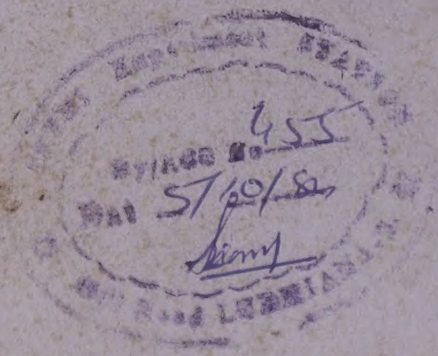
Shri S. D. THIRUMALA RAO,

Director,

Oil Technological Research Institute, Anantpur

For His Project Report On

Technology Of Production And Utilization Of Rice Bran Oil For Edible Purpose



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Technology Of Production And Utilization Of Rice Bran Oil For Edible Purpose

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LABHETA SIKATASU TAILAMAPI YATNATAH PEEDAYAN

-Bharthari.-

'.....whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together'

The King of Brobdingaag in 'Gulliver's Travels' -

by -Jonathan Swift.

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CHAPTER : I

A SURVEY OF RICE BRAN OIL INDUSTRY

The countries in which rice bran oil industry is in existence ar Japan, U.S.A., Chile and Burma. In India, rice bran oil is being produced since early sixties.

A brief survey of various facets of the industry in these countries is made hereunder :

JAPAN.

Cage Process: Rice bran oil industry took shape in Japan by 1938 and by 1939 about 17,000 tonnes of rice bran oil was being produced annually mostly by cage presses. The characteristics of cage-pressed Japanese rice bran oils are given in Table - 1.

Table - 1.

Characteristics of Japanese cage-pressea rice bran oils:

Crude oil	Characteristics
FFA	3.8%
Colour (Lovibond 5¼" cell)	150Y, 16R
Refining loss	13.5%
Refined oil:	
Colour of refined oil	150Y, 2B, 12R
Colour of bleached oil	70Y, 5B, 9.8R
FFA	0.06%
Unsaponifiable matter	2.9%
Iodine value (R-K)	108.9

In post-war period, the industry gained much impetus due to the advent of solvent extraction system. In 1959, of the total of 30,000 tonnes of rice bran oil produced, one third was edible grade oil.

Extraction plants:

Boso Oil and Fat Industry Company and Tokyo Oil and Fat Industry Company Limited are large plants with capacities

of over 100 tonnes of bran per day. The above two major concerns have not only evolved their own processes of rice bran extraction and oil refining, but also their plants for export. Boso system of rice bran extraction plants are reported to be working in Burma addition, Suzuki Ryoshoku Kenkyusho Company Limited offers small solvent Extraction plants of 10 tonnes capacity.

Uses of oil and meal.

Edible oil:- Dewaxed, neutralized and decolourized and decdourized oil has good taste. The catch phrase of one of the major rice oil producers in "Olive oil in Europe, rice oil in Japan". One third of total production of oil is of edible grade.

Industrial oil :- High-acid oil is used for soap and chemical industries.

Extracted meal :- Extracted meal is used as cattle feed and is preferred to original bran which is reported to cause loose bowels in cattle.

Characteristios of rice bran and oil

According to an analysis of Boso Oil and Fat Industry Company Ltd., the following oil contents are given for white rice bran of different countries.

Table 2

Oil contents of rice bran of different countries.

Country	Oil content of rice bran percent
Burma (Boiled)	18
" (Raw)	12-18
China	19-21
Taiwan	15-18
India (Boiled) Sela (for boiled)	18-25
" (Raw)	12-15
Pakistan	6-12
Indonesia	4-8
Philippines	5-15
Thailand	8-19
Combodia	5-13
Australia	20
Egypt	15
U.S.A.	13-15

Table 3

Characteristics of Japanese rice bran oils

Characteristics	Value
Acid Value	Min. 10 Max. 150 Av. 20-60
Saponification value	180-195
Iodine value	90-110
Unsaponifiable matter	4-7 percent.

Japanese Agricultural Standards (J.A.S.) for rice bran oil are given in Table 4.

Table 4

Japanese Agricultural Standards for rice bran oils

Characteristics	Crude oil	Edible oil
1. General condition	Clear at 80 C	Clear deliciousstaste mild flavour.
2. Colour	—	Lovibond 5¼" cell 35Y+10R.
3. Moisture and impurity max. %	2.0	0.2
4. Unsaponifiable matter max. %	7.0	4.5
5. Spacific Gravity	0.845-0.875 (100°C/40°)	0.915-0.919 (30° C/20)
6. Refractive Index	—	1.470-1.473 (at 30° C)
7. Cold Test	—	0°C 15 min.
8. Acid Value	—	1.0
9. Saponification value	180-195	180-195
10. Iodine value	92-112	92-115

No official standards for rice bran or meal are prescribed. Oil industry in Japan is becoming automatized in recent years.

U.S.A.

The development of rice bran oil industry in U.S.A is the result of a research work initiated in 1947 at Southern Regional Research Laboratory, New Orleans. It is historically interesting to note that among the workers in the pioneering research team, two are from India, namely, K.S.Murti and P.B.V.Reddy. They were awarded "Superior

Service Award" by the U.S. Government in view of their co tribution to post-war reconstruction efforts in the United States.

In earlier years, 2,500-5,000 tonnes of rice bran oil were imported into U.S.A. principally from Japan. The rice bran oil production in U.S.A. rose steadily from negligible quantity prior to 1947 to several thousand tonnes by 1951.

The position till 1960 is as follows:
One plant is operated by Rice Growers' Association of California, Sacramento. It has a capacity for processing 100 tonnes of rice bran per day and has been producing 2-3 thousand tonnes of oil annually. The second plant is operated by Coment Rice Mills at Houston, Taxas. It has also a capacity of 100 tonnes of bran per day and produced 2-3 thousand tonnes of oil annually. Both the plants produce edible grade oil. There is a potential of about 330 tonnes of wax per year. The average yield of oil is 14 percent and the yield of bran from paddy (Rough rice) is 8.5 percent. The samples of rice bran oils obtained from the two U.S. plants referred to above had the following characteristics as examined at Oil Technological Research Institute, Anantapur.
Table 5 gives the data.

Uses of rice bran oil, meal and wax.

Oil :- (I) The major market (75 percent), to day for rice oil is for edible purposes, particularly in the manufacture of oleo and cooking oils and popcorn oil. Refined and winterized oil is reported to be superior for mayonnaise, salad dressings and other emulsified products. In tests conducted compering rice oil with the most expensive brands of cottonseed, corn and peanut oils for frying shrimp, chicken, onion rings and fish, the rice oil fried the food faster, gave a more golden colour and foods fried in rice oil absorbed less oil. It does not impart a flavour to

TABLE- 5

Characteristics of rice bran oils of U.S.Origin analysed at O.T.R.I.,Anantpur.

		Rice Bran Oil from											
		Rice Growers' Asson. California						Commet Rice Mills Dallas -			1 Texas		
		Crude oil			Salad oil			Crude oil			Refined Bleached and deodorized oil		
Colour of Oil	Visual	Light Brown clear at Lab.Temp.			Yellow			Cloudy & brown at Lab.Temp.			Yellow		
		Y	B	R	Y	B	R	Y	B	R	Y	B	R
	1" cell	70	0	8	8.3	0	0.9	45	0	12	6.2	0	0.6
	5½" cell				35	0	5				35	0	4
F.F.A.	....	1.7			0.10			10.9			0.10		
Saponification value	....	186.4			186.8			184.9			186.4		
Iodine value(Wijs)	....	118.4			119.0			110.6			107.3		
Wax content	....	4.8			Nil			5.1			Nil		
Refractive Index(40°C)	....	1.470			1.470			1.468			1.469		

foods and does not pick up food flavours. Rice oil is being used by bakeries in various parts of the country. They report good results with it as a pan release, as one problem of many bakeries is to find an economically priced products that will release bread from pans after baking without gumming up the pans or the bread.

(II) Rice bran oil is also used in small quantities as a carrier for insecticides and for making mesh bags and other industrial uses-25 percent of estimated 1958 sales.

(III) Comet Rice Mills reported to have developed an anti-rust oil by combining rice oil with a secret drying agent. The oil is combined with the drying agent in various proportions to make corrosion inhibitors, with drying times ranging from 3-5 hrs. to 7-10 days. A slow-drying oil is intended to loosen the rust on a surface that has already corroded, while a fast-drying combination would quickly put a protective coating on clean metal.

(IV) Rice bran oil has been reported to be used experimentally by steel companies, ship-builders and gas pipe lines. T-stress Inc., Houston, uses it to line moulds for casting concrete. One chemical concern in Houston is reported to have added some ingredients of its own and marketed the product as "Bindox".

No reliable figures are available on the quantities of rice oil used for specific purposes. Consumers of the commodity consider and uses somewhat as trade secrets.

Extracted bran meal: As far as is known, the extracted meal is used as a feed ingredient. The removal of lipids produces a free flowing material very light in colour and weight, diffecult to handle and inclined to dust. Lightness increases losses in handling. This problem is lessened by addition of 3 percent feed grade molasses. Pelletization of the low fat meal is also being made.

Wax: Though in the earlier stages of industry it was dubbled as "nuisance", research is under way to exploiet this useful commodity, " a byproduct of a by-product". The hard component of the wax mixture (M.P.79°C) appears to have characteristics that would make it suitable for specialized applications where other hard vegetable waxes are used. The situation in this field is undergoing changes with the advent of synthetic ingredients of polish finishes.

Specifications.

Bran and meal : There are no official U.S. specifications for domestic or export for rice bran or its products, comparable to those of cottonseed products. Specifications are matters agreed upon between suppliers and consumers. Domestic specifications vary in accordance with regulations for animal feeds, although these variations are relatively minor with the average specifying (a) not less than 11 percent protein and (b) not more than 15 percent fibre. The extracted meal should contain not less than 14 percent protein and not more than 14 percent fibre.

Oil : As to the case of bran and meal, there are no official standards for oil. Requirements are established by agreement between the buyer and the seller. Crude rice bran oil varies considerably depending on the method of production but this variation is mostly of free fatty acid content (FFA). They have got a penalty clause in their purchase contracts to compensate for FFA above 4 percent. The various feed control services of states also do not have any specifications for oil except that any person wishing to sell rice bran oil in the feed trade must file a set of his own specifications, showing the total amount of fat, the amount of unsaponifiables and the lime.

When compared to other vegetable oil industries, for instance cottonseed and soybean oils, rice bran oil industry is pretty small in U.S.A. constituting below 4 percent of their production.

CHILE

A solvent extraction plant using the "filtration extraction" process has been installed by Cia Productors National de Aceites, Santiago. This plant was designed and constructed by Wurster & Sanger, Inc., Chicago. The plant uses hexane and processes 50 metric tons of rice bran per day. Rice bran oil recovered is about 14 percent by weight of bran. The oil is refined and sold for salads and cooking.

BURMA

While the development of rice bran oil industry in Japan and U.S.A. was a sequel to the development research and the well established technological and industrial traditions of those countries, the position with regard to Burma is quite different.

Burma is an agricultural country occupying a prominent position in paddy production. The main agro-industry is rice-milling. There are many rice mills, some smaller and the others larger, dispressed over the country. Ninety percent of the mills are sheller type, with the result that high quality bran is produced which is known to have a great demand in London market for cattlefeed.

Centres of rice-milling industry are around the cities of Rangoon, Moulmein and Bassein. In these centres, there are rice mills having capacities between 100-200 tons per day.

Rice bran extraction plants :- The first rice bran extraction plant was erected in 1958 in Rangoon a Boso system extraction and refining plant, with a daily capacity of 45 tons. By the end of 1958, another plant of 24 tons capacity was supplied to a private

party by DIA Chemieausrustungen, an exporting organisation of the manufacturers of the plant, VEB Maschien and Apparatebau Grimma, East Germany. The same plant was expanded to 40 tons capacity in 1959. The same organisation has arranged to supply two more plants of 50 tons capacity each to two Burmese firms. The description and performance of this plant has been given in "German Export".

The State Agricultural Marketing Board of Burma (S.A.M.B.) which is a government purchasing and selling organization controlling all rice exports from Burma has taken an active lead in procuring solvent extraction plants. The Industry Ministry of Burma is reported to have agreed to purchase 12 complete rice bran extraction plants through the Board. Three out of these 12 plants are to be supplied by DIA Chemieausrustungen, GDR, East Germany, one plant of 25 tons capacity by Messers. Schantung Limited, West Germany and 8 plants by Japan, the last named country to supply free of cost towards the war reparations to Burma. Thus, when all these plants go into production, Burma will be one of the leading rice bran oil producing countries of the world.

One of the plants in Rangoon, Messrs. Burma Agricultural Oil Producing Mill, has also imported a refining unit and refines the crude rice bran oil when the FFA is below 15 percent producing edible oil. Rice bran oil with higher FFA is used in soap industry.

The extracted bran exported from burma is sold in the London market on the basis of 18 percent oil and albuminoids and 4 percent sand and silica, with an allowance of 1 percent for each 1 percent of deficiency of oil and albuminoids and excess of sand and silica. Because of the superior quality of the extracted bran produced in Burma, it finds sustained demand in European market. The ruling rate in 1960 for the extracted bran from Burma was from £ 17 to £ 20 per ton.

Not much headway has been made in the recovery of wax in the Boso system plant supplied in 1957, wax is gained through filtration by means of cotton bags, in open air. This process is reported to be unsatisfactory. It will be successful, it is assumed, only when the product has previously been cooled down to 20°C.

The Union of Burma Applied Research Institute, Yankin, Rangoon, has intimated us that one project on rice bran oil is on hand with them concerning stabilization of bran and optimum conditions of bran storage.

INDIA

Upto 1959 it was not possible to get even small quantities of commercially-produced rice bran oils for curiosity. As on 1974, about 65,000 of tonnes of rice bran oil are estimated to be produced annually in our country (vide infra). This gives in a nutshell, the development of the Indian rice bran oil industry.

The following factors have given impetus to the development of rice bran oil industry in India.

(I) Manufacture and supply of sound solvent extraction plants by indigenous engineering firms at reasonable rates.

(II) Increasing production and availability of commercial normal hexane solvent.

(III) Relative abundance of raw material i.e. rice bran at cheap prices.

(IV) The encouragement being given by Govt. of India to rice bran oil industry sequel to the recommendations of Adhoc Committee for Rice Bran Oil Industry set up in 1959-60 by the ministry of commerce and industry, Govt. of India. The recommendations of the above committee are given in Annexure-1 to this chapter.

(V) Increasing demand for oils for industrial and edible purposes.

(VI) Research work done by laboratories like Oil Technological Research Institute, Anantapur and other research institutions.

India produces about 60 million tonnes of paddy yielding over 3.5 million tonnes of rice bran from which about 0.5 million tonnes of rice bran oil would be made available annually. Currently only 60 to 65 thousand tonnes of rice bran oil of which 5,000 tonnes are said to be of edible quality, are being produced in the country. Another estimate puts the figure that is half of it. As early as 1966 an attempt was made by an industrial concern in Andhra Pradesh to produce edible grade rice bran oil by extracting fresh rice bran, refining it in continuous centrifugal refiner and bleaching and deodourization. The above refined oil was tested at Oil Technological Research Institute, Anantapur. It was reported to be yellow in colour and bland in flavour and had high flash point of 500°F. The cooking performance of the oil for 'Bajjis' and potato chips was sutdied under deep frying condition. The products were very good and comparable with groundnut oil products. The consumer acceptability was excellent. The keeping quality of the products has also satisfactory in study of 48 hrs. Some of the salient characteristics of the oil before and after frying are given in Table 6.

Table 6.

Characteristics of edible rice bran oil before and after frying (CTRI data):

Sl. No.	Characteristics	Before frying	After frying
1.	Visual colour	Yellow	Orange
2.	Lovibond colour 1" cell (Y+10R unit)	20	40
3.	FFA	0.27	0.28
4.	Peroxide value	5.0	12.0

Though the solvent estraction industry in the country is growing rapidly, adequate importance is not being

given to rice bran oil. Hardly 30 to 35 plants are processing rice bran out of about 200 plants extent in the country. Even assuming that 50% of the total rice bran produced in the country is made available for recovery of oil, there is a scope to establish another 50-60 solvent extraction plants for extraction of rice bran oil alone.

The rice bran oil has got a ready market. It is mainly used in soapmaking. At present the oil requirements of the soap industry alone are estimated to be around 4 lakh tonnes. For want of adequate supply of non-edible oils, the industry is unable to expand rapidly and also unavoidably consumes nearly 50,000 tonnes of edible oils particularly groundnut oil and coconut oil. The soap industry can easily release edible oils if adequate rice bran oil and other non-edible oils are made available, The use of rice bran oil in soap making is being encouraged by the Government of India. It is necessary to encourage the rice bran extraction industry to produce more and more rice bran oil to meet the rising demand of the soap industry.

So far, the oil produced from rice bran contains high free fatty acid contents and as such, it is unfit for edible purposes.

Steps are also now a-foot to obtain edible grade rice bran oil, On September 22, 1974 a Seminar on Modernisation of Rice Milling was held at Calcutta, under the joint auspices of the East India Rice Mills Association, Calcutta and the Ministry of Food and Agriculture, Government of India to emphasise stabilization of rice bran among others. It is hoped that the findings of this seminar would be utilized by the industry. It would, therefore, be not long before the heat-treated stable bran is made available to the rice bran extraction plants to obtain edible grade rice bran oil.

One enabling suggestion is that the new entrepreneurs should establish their extraction plants in small capacities in close proximity to rice mills so that the supply of fresh rice bran could be ensured.

Out of nearly 3.5 million tonnes of rice bran produced in the country, over 0.2 million tonnes of rice bran is estimated to be solvent extracted for oil. The rest is consumed directly as polutry and cattle feeds. But as deoiled rice bran is nutritively superior to raw rice bran as an animal and polutry feeds, it is desirable to extract all the available bran to increase our oil resources as well as improve the nutritive value of rice bran.

Addresses of manufacturers of solvent extraction plants:

1.	Servotech	Bombay
2.	De-Smet	Bombay
3.	Trioka	Bombay
4.	Vasant Industries	Bombay
5.	Chemical Construction Company (P) Ltd.,	New Delhi/Madras

Addresses of some producers of rice bran oil in India:

1. K.N. Oil Industries, Mahasamund, Raipur (dist.),M.P.
2. Omrao Industrial Corpn.Pvt. Ltd., 54 Mill area, Kanpur, U.P.
3. Khandesh Extractions, P.B. No. 8, Chalisgaon, Maharashtra.
4. India Oils & Fertilizers Corpn., 270/3, Chettigunta Road, Nawabpet, Nellore-2. A.P.
5. Subbaraya Solvent Oil Extraction Pvt. Ltd., Sarpavaram, P.B.No. 87, Kakinada-3. A.P.
6. Prag Ice & Oil Mills, Baraf Khana, Aligarh, U.P.
7. Gujarat Extraction Ind., 469/12, Rangwala Chawl, Opp. Maskathi Market, Ahemedabad-2. (Gujarat).
8. Motilal Hariprasad & Bros. Sangadigunta, Guntur-2. A.P.
9. Foods Fats & Fertilizers Ltd., Tadepalliguden, West Godavari Dist. A.P.
10. Balaji Industries, 19th Ward, Bhimavaram, West Godavari Dist.Ap.

11. A.P. Co-op. Market Federation, Autonagar, Vijayawada.2. A.P.
12. Adoni Solvent Oil Co., Mantralayam Road, Adoni, A.P.
13. Gajanana Rice & Oil Industries, Mysore.
14. Kamani Oil Mills, Chandiwali Estate, Sakinaka, Bombay-72
15. Venus Oil & Fertilizers Pvt. Ltd., 15, Ornes Road, Kilpauk, Madras-10
16. Vegetable Oils & Chemical Industries, Nepalipatty, Tezpur (Assam).
17. Daccan Solvent Extractions Pvt. Ltd, Kodad (A.P.)
18. Khosla Oil & General Mills, New Delhi.
19. Seemas Oil Mills (P) Ltd., Industrial Estate, Bilaspur (M.P.)
20. Marked Vanaspati & Allied Industries, P.B. No.23, G.T. Road, Khanna (Ludiana Dist.) Punjab.
21. Shree Gopal Rice & Oil Mills, P.O. Bilha (M.P.)
22. Shree Ventateswara Chemical Industries, Machavaram, Machillipatnam-2.
23. Rajrishi Chemical Industries, Pipli Road, Kurukshetra (Haryana)
24. New Dewan Oil Mills, 93/ , Industrial Area, Chandigarh.
25. Lal Oil and General Mills, G.T. Road, Chheharta, Amritsar (Punjab).
26. Saraswati Extraction Agency, Pipli Road, Kurukshetra (Haryana).
27. Rice Bran Solvent Oil Extraction Mills, Durg (M.P.)
28. Agro Industries Oil Extractions Ltd., Pareja, Ahmedabad.
29. Sarda Oil & Rice Mills, Ahamadpur P.O. Bhirbhim dist. W.Bengal.
30. Seth Oil Mills Pvt. Ltd., (a) Industrial Area, P.O. Box. No. 21/25, Raipur (M.P.)

    (b) Kashmir Road, Amritsar (Punjab.)

There are several plants in W.Bengal, Bihar, Punjab and Haryana extracting rice bran oil. The number of h-ullers and shellers are given in Table 7.

Table 7.

Hullers and shellers in India.

State	Hullers/Huller mills.	Sheller/sheller mills.
Andhra Pradesh	3045 small hullers	916
Assam	246 mills	nil
Bombay	3229 mills	509
Bihar	146 huller mills 620 small hullers	2 sheller mills
Travancore & Cochin	20 huller mills 388 hullers	2 sheller mills
Madhya Pradesh	312 huller mills	413 sheller mills
Madras	5957 huller mills	126 "
Mysore	1768 huller mills	282 "
Punjab	800 huller mills	20 "
Orissa	88 huller mills (automatic)	
	500 hullers	nil
Uttar Pradesh	1376 huller type machines.	120 sheller type machines.
West Bengal	388 huller "	15 sheller type (7 are purely sheller type and 8 are sheller huller combined)

Source: Report of the Rice Milling Committee 1955, Ministry of Food and Agriculture, Government of India.

Latest estimates indicate the total number of rice mills under operation by 1973 was 83,607 most of which were of single huller type. At present there are about 100 "modern" rice mills working in the country. The capacity of a modern rice mill is said to be about 100 tonnes of paddy per day.

It is well known that parboiling is extensively carried out. For the whole country, production of raw rice is 43 percent and parboiled rice 57 percent. Figures vary from state to state-see Table 8.

Table 8.

Percentage of raw and Parboiled Rice Produced in Different States.

States	Raw rice	Par-boiled rice.
West Bengal	10	90
Bihar	10	90
Orissa	10	90
Kerala	8	92
Madhya Pradesh	68	32
Madras (Composits)	95	5
Uttar Pradesh	88	12
Bombay	96	4
Punjab	95	5
Assam	58	42

Source: Report on the Marketting of Rice in India (Second Edition) 1955

Export of rice bran:

During the years 1957 and 1958, about one thousand and five thousand tonnes respectively of rice bran (original) were reported to have been exported at an estimated value of Rs. 1.5 and Rs. 7.7 lakhs. After advent of solvent extraction industry, export of original rice bran is banned and only "extraction" i.e. extracted meal is exported. The deoiled bran is now exported to U.K., U.S.A., Poland, Czechoslovakia, Hungry and Japan. The export fingures of deoiled rice bran are given in Table 9.

Table 9

Export of rice bran extractions .

Year	Quantity '000 tonnes	Value in Crores (Rs.)
1967-68	53.47	1.20
1968-69	63.62	1.44
1969-70	81.62	2.01
1971-72	146.93	2.56
1972-73	117.72	2.36
1973-74	106.47	3.57

There is thus a spectacular increase in exports for deoiled bran in recent years.

Specifications of deoiled rice bran:

The export specifications for deoiled rice bran as given by the Economic and Statistical Adviser, Ministry of Food & Agriculture, Govt. of India are as follows :-

Crude protein	Not less than 10%
Ether extract	Not more than 3.5%
Crude fibre	Not more than 20%

According to the London Cattlefeed Traders' Association, the specifications are:

Oil and albuminoids	Not less than 16%
Sand and silica	Not more than 8%

* * * * *

A N N E X U R E -1.

Recommendations of Adhoc Committee on Rice Bran Oil industry Constituted by Government of India in 1959:

(1) Initially the quantity of 3 lakhs tonnes of rice bran that goes to the market could be processed to yield about 20,000 tonnes of oil. This would mean extraction of hardly 15 percent of 9,00,000 tonnes of rice bran which is the estimated production in the country.

(2)····· Rice bran extraction plants should preferably be located within a radius of 50 miles from the concentration of rice mills in order to ensure quick and economical transport of the raw material.

(3)····· There should be hydraulic-pressing of rice bran and deoiled bran to save storage space and cost of transport.

(4)·····The organisation of the industry should be on co-operative lines particularly by a group of rice mills.

(5)····· The continuous type of rice bran oil plant of capacity ranging from 25 to 50 tonnes per day of 24 hours in terms of rice bran would be economical units, Smaller batch type plants may also be installed in areas where the availability of rice bran is limited.

(6) ·····The existing hullers should be modernised into sheller type of rice bran mills without substantially increasing of over-all regional milling capacity.

(7) ..... The bran obtained from hullers could be improved to some extent by sieving before and after extraction.

(8) (i) Rice bran oil mills should set up separators to remove broken rice, germs, stones and dirt, from the bran and also install specially designed pneumatic separators to remove the husk from the bran.

(ii)Suitable designs of such separators should be evolved by the National Laboratories/Oil Technological Research Institutes inthe country.

(9) (i) The bran should be stabilised by heat treatment and drying to 2 to 3 percent moisture content soon after its separation from rice . The stabilising equipment should be set up in large sheller type of rice mills or alternatively in rice bran extraction plant.

(ii) It would be advantageous if suitable type of equipment for drying and stabilisation of rice bran could be designed by the National Laboratories/ Oil Technological Research Institutes.

(10) The investigational work on the refining, bleaching, deodorisation and hydrogenation of the oil should be carried out in the National Laboratories / Oil Technological Research Institutes.

(11) The rice bran oil mills may be permitted to import suitable continuous plants to refine the oil.

(12) In the initial stage of development of the industry, rice bran oil is likely to have high free fatty acids and, therefore, the oil should be used in the unrefined stage for industrial purposes, e.g., manufacture of soaps and as raw material for fat splitting and fatty acid distillation among with other oils.

(13) Wax should be recovered from the extracted oil by centrifuging it.

(14) Rice bran oil need not be considered for export till refined oil of standard quality is produced. Standards should immediately be framed by the I.S.I., New Delhi, for rice bran and de-oiled rice bran (particularly for export purposes)

(15) It is advantageous to use extracted rice bran as cattle feed and so the use of de-oiled rice bran as cattle feed should be popularised.

(16) Rice bran and cottonseed should be placed in the same category for railway frieght to enable extraction plants of transport de-oiled bran to different places more economically than at present.

C H A P T E R : II

RICE BRAN AND OIL - QUALITY CONSIDERATION.

Rice bran is obtained as a by-product during rice milling. Commercial rice bran consists of rice polish, aleurone layer and germ. This comprises about 6% by weight (dry basis) of "rough rice" or "paddy rice". Yields of these products are given in Table I.

Table 1.

Yields of different fractions during rice milling.

S.No.	Fraction	Yield percent.
1.	Hulls	25
2.	Head rice	65
3.	Bran	8
4.	Germa	2

Germs generally come mixed up in bran

Rice Bran

Characteristics and composition:

The quality of rice bran produced in the rice milling industry is the most important factor in the rice bran oil industry. Generally, hullers and shellers are in vogue for rice milling. In recent years, what are known as "modern rice mills", which are large capacity units with rubber polishers, have come into existence in the rice growing states of the country. The bran produced in the huller and sheller rice mills differ markedly in their composition and characteristics. Huller rice bran is coarse in texture, low in oil and protein and high in ash sand and silica and fibre. Sheller variety rice bran is fine in texture, high in oil & protein relatively low in ash, sand and silica and fibre. Parboiling of paddy increases the quality of head rice. The relative qualities of huller, sheller and modern rice mill-produced bran are given in Table 2.

Characteristics of rice bran from hullers, shellers and modern rice mills(OTRI data)

S.No.	Variety	Moisture percent	Oil percent	Protein percent	Ash Total percent	Ash Insoluble percent	Crude Fibre percent
1.	Raw						
	Huller	8.0-9.5 (8.9)	5.0-10.0 (7.5)	5.5-9.5 (8.0)	13.5-22.5 (17.9)	2.0-19.0 (12.7)	5.8-22.7 (16.8)
	Sheller	8.5-11.5 (9.7)	11.5-19.0 (15.7)	9.0-13.0 (11.9)	8.0-22.5 (12.9)	3.5-19.0 (8.0)	6.0-14.5 (9.2)
2.	Parboiled						
	Huller	4.0-9.5 (8.0)	6.5-12.5 (10.0)	4.5-9.5 (7.5)	17.5-20.0 (19.0)	14.5-18.5 (16.5)	20.5-30.0 (22.3)
	Sheller	3.0-11.5 (7.5)	12.0-27.5 (20.5)	10.0-15.5 (12.0)	8.5-22.5 (14.2)	3.0-21.0 (9.0)	6.5-32.0 (16.0)
3.	Modern Rice Mills	8.0-9.5 (9.0)	15.0-18.5 (16.5)	13.0-14.0 (13.5)	9.0-11.5 (10.5)	2.5-4.5 (3.5)	8.5-10.5 (9.5)

Figures in bracket are average.

The Indian Standards Specification for rice bran is given in IS: 3648 - 1966.

The essential requirements of the specification are given in Table 3.

Table 3.

Indian Standard Specification IS:3648 - 1966 for Rice Bran.

S.No.	Characteristics	Requirement for original bran
1.	Moisture percent by weight, Max	12
2.	Crude protein (nitrogen 6.25) percent by weight, Min.	11
3.	Crude fat or ether extract percent by weight, Min.	12
4.	Crude fibre, percent by weight, Max.	12
5.	Total ash, percent by weight, Max.	13
6.	Acid-insoluble ash percent by weight, Max.	4

It is seen that rice bran from sheller mills and "modern rice mills" satisfies the requirements laid down by the ISI. For the recovery of oil through solvent extraction, these two varieties of bran are economical. However, in India, there are about 45,000 to 50,000 rice hullers, where-as there are only about 10,000 to 20,000 sheller mills and about 100 modern rice mills. The Government of India are presently contemplating to arrest the growth of huller mills through their switchover to sheller or modern type rice mills in view of the increase in the yield of head rice and the quality of bran produced. Another measure to increase the head rice yield and its nutritive quality and quality of rice bran is paraboiling the paddy. This is being practised in many parts of the country. Rice germs are also contained in the commercial rice bran to the extent of 16 percent on the weight of bran.

The composition of rice germs and characteristics of rice germ oil are given in Tables 4 and 5 respectively.

Table 4.

Composition of rice germs.

S.No.	Composition	percent
1.	Moisture	10.3
2.	protein	17.0
3.	Oil	22.0
4.	Total ash	5.3
5.	Crude fibres	6.2

Table 5.

Characteristics of rice bran oil

S.No.	Characteristics	
1.	Iodine value (Wijis)	99.2
2.	Saponification value	190
3.	Unsaponificiable matter, percent	5.2
4.	Free fatty acid content	45.3

Rice Bran Oil:

Composition and characteristics:

The quality of the oil depends upon the methods by which it is produced, especially upon the time which elapses between the milling of rice and removal of oil from the bran. The characteristics of oils from raw and parboiled rice bran are given in table 6 (page 2-6) Fatty acid composition is given in Table 7.

Special Characteristics of Rice Bran Oil:

The wax content of rice bran oil ranges from 1.5 to 20% but mostly about 3% which is higher than in other usual vegetable oils. The chlorophyll content of the rice bran oil ranges from nil to 20 ppm.(OTRI data).

Table 6.

Characteristics of oils (laboratory extracted) from raw and parboiled rice bran (CFTRI data)

S.No. Variety	Iodine Value (Wijs)	Saponification Value	Wax content percent	Colour of oil Visual	Lovibond in 1/4" cell (Y)	(R)	(B)	Chlorophyll ppm
1. Oil from raw bran	84.95 (90)	170-190 (182)	3-20 (12.1)	Dark green to yellowish brown	9-20 (15.5)	1-4 (1.5)	1-4 (2.5)	5-20 (11.3)
2. Oil from par boiled bran.	85-100 (93)	181-197 (185)	1.5-6.5 (3.2)	Yellow to greenish yellow	6-18 (15)	1-5 (2.0)	0-6 (1.5)	0-9.5 (6.2)

(Figures in brackets are averages)

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Table 7.

Fatty Acids in Rice Bran Oil.

S.No.	Component acids	percent range
1.	Saturated acids	16-20
	(i) Myristic	0.4-1
	(ii) Palmitic	13-18
	(iii) Stearic	1-3
2.	Unsaturated acids	80-85
	(i) Oleic	40-50
	(ii) Linoleic	29-42
	(iii) Linolenic	0-1

Table 8.

Indian Standards Specification IS:3448-1968 for Rice bran oil

S.No.	Characteristics	Requirements for Refined Grade	Grade I (raw)	Grade 2 (Raw).
(i)	Moisture and insoluble impurities, percent Max.	0-10	0-5	1.0
(ii)	Colour in 1"-cell on the Lovibond scale expressed as Y+5R not deeper than	20 (No dominent green colour)	-	-
(iii)	Refractive Index at 40°C	1.4600 to 1.4700	1.4600 to 1.4700	1.4600 to 1.4700
(iv)	Specific gravity 30°/30°C	0.910 to 0.920	0.910 to 0.920	0.910 to 0.920
(v)	Saponification Value	180 to 195	175 to 195	175 to 195
(vi)	Iodine Value (Wijs)	90 to 105	85 to 105	85 to 105
(vii)	Acid Value Max.	0.5	40	80
(viii)	Unsaponifiable matter percent, by weight, Max.	3.0	6.0	6.0
(ix)	Flash Point Pensky-Martens (Closed) °C Min.	250	100	90

The squalene content of the rice bran oil varies from 202mg/100g to289mg/100g which is remarkably high when compared to groundnut oil (22.9mg/100g) and cottonseed oil (27m·/100g) (OTRI data). It is observed that oils from non-seed origins do contain higher quantities of sqalene, a polyunsaturated aliphatic hydrocarbon, e.g. Olive oil 136-708 100g, and fish liver oils ranging from 220--90,000 mg/100g. Rice bran oil contains a series of unusual phenolic substances collectively called "oryzanols". This mixture is found to be composed of three related substances. They are,-(i) Oryzonol A-0.04% in the oil. It is cycloartenyl ferulate. (ii) Oryzanol B-0.035% in oil, a mixture of oryzanol A and C and (iii) Oryzanol C,-0.028% in oil. It is 24-methylene cycloartenyl ferulate. These constituents are compounds of phenolic and ferulic acids (monoethyl ether of 3:4 dihyroxy cinnamic acid) and triterpene alcohol, cycloartenol and its dihydride cycloartenol. The peculiar odour of rice bran oil might be due to these and squalene.

The Indian Standards Specification for rice bran oil is given in IS:3448 - 1968. The essential requirement for various grades of rice bran oils are given in Table '8

Grades of Oils

(a)Re-fined Grade (for direct edible consumption)
(b) Grade 1 (Raw) for making refined oil and for other industrial uses, and
(c) Grade 2 (Raw) for industrial uses other than for making refined oil.

C H A P T E R III

PROBLEMS OF EDIBLE RICE BRAN OIL INDUSTRY.

Rice bran processing is problem-ridden

In Table 1, problems of edible rice bran oil industry are given in a nutshell with suggestions for their solution.

Table 1.

Problems & solutions of edible rice bran oil processing.

Sl. No.	Problem	Solution	reference number in Chapter7
(1)	(2)	(3)	(4)
	Paddy Milling:		
1.	Milling in Huller	Avoid huller	-
	Sheller Modern Rice Mill	Adopt latter two	-
2.	Parboiling or raw	Optional	--
	Bran:		
3.	Rapid rise of Free fatty acids.	(i)Extract immediately	-
		(ii)Store in cold	(11)
		(iii) Heat Stabilize	(17) & (32)
4.	Selection of Bran:		
	(i) High sand & silica contents:	Rapid "field" method of estimation	(25)
	(ii) Low Oil	-do-	(25)
	(iii)High Oil	"Hone" method of determination	(28)
5.	**Extraction:**		
	"Fines" problem:	(i)Pelletization	-
		(ii)Crisping	-
		(iii) "Expansion"	-
	Oil		
6.	Presence of Wax	(i) Settling	-
		(ii) Chilling	-
		(iii) Centrifuging	-
7.	High refining losses.	(i) Continuous Centrifugal refining	-
		(ii) Use of additives when refining by batch process	(5& 22)
		(iii)Deacidification by distilling followed by alkali neutralization	(22)
		(iv) Molecular distillation or physical refining	(13)

(1)	(2)	(3)	(4)
8.	Green colour	Pretreatment with oxalic, citric, tartaric or malic acids followed by absorption bleaching with earth and carbon.	(9&20)
9.	"Brany" odour	deodourize the oil with super heated steam	
10.	High Unsaponifiable matter.	Dewaxing and deodourizition	
	Meal		
11.	High sand and silica	(i) Air classification (ii) Differential settling (iii) Sieving	(31)
12.	Fluffiness and bulkiness	Hydraulic-pressing	(12)
13.	Spontaneous combustion	storing of dry bran in airy space	-
14.	Dustiness	Blending with mollases	-

1. Hullers, shellers and "modern" rice milling.

There are three types of rice mills namely hullers, shellers and modern rice mills. Except the bran produced in huller mills, the other two varieties of bran rice suitable and economical for solvent extraction purposes, but huller mills are huge in number because (1) the investment required is very low and hence suitable for small entreprenuers. (2) The unit is compact and easy to operate (3) Capacity is low and therefore attractive to small quantity paddy holders and (4) maintenance cost is low. As against these, the investiment required for shellers and modern rice mills is huge and prohibitive. These units are large and their machanisms are complex.

As capacities are very big, large quantities of paddy are required for milling. People having small quantities of paddy can'ot take their paddy to these units. The maintenance costs of units are considerably higher.

It is, necessary for the government to provide suitable financial assistance to huller millers to modernise their mills on scientific lines in order to obtain better yields and qualities of head rice and by products. Further, the government should stop licensing of huller mills in future and be made mandatory to convert the existing hullers into shellers. Research should be undertaken to develop small capacity shellers so that paddy milling with shellers could be done on rural industry basis in villages.

3. Parboiling

Paddy is milled asharvested or parboiled before milling. Parboiling is prevalent in many states. Choice between raw rice & parboiled rice is a matter of taste and habit. In Chapter 1, Table 7 are given the percentages of rice parboiled in each state. According to nutritionists and food technologists, modern parboiling of reputation paddy has got many advantages like minimization of "brokens" during paddy milling, improvement in cokking quality, increase of nutritional value and vitamin content. It is also seen that oil from parboiled bran would generally be yellowish in colour in contract to green colour of oil from raw bran. Green colour is a problem in the way of utilization of oil for edible purposes.

4. Rapid rise of free fatty acids.

To manufacture edible grade oil from rice bran, the extracted oil should have low free fatty acid, about 3 maximum so that it could be refined, bleached and deodourized economically. Oils with high free fatty

acid contents are not amenable for refining because of heavy losses and other complications like emulsions, loose foots etc. Table 2 shows the rapid rise of free fatty acids in the fresh samples of bran.

Table 2.

Increase of ffa in rice bran(OTRI data)

Sl. No.	Storage period in hours 0	2	4	6	Storage period in days 1	3	5	10
1.	1.99	2.68	3.34	4.00	6.77	11.82	16.22	24.79
2.	1.10	1.42	1.60	2.44	3.07	5.68	8.28	13.81
3.	1.18	1.62	1.82	2.15	3.71	7.55	-	15.90
4.	2.37	3.67	4.23	4.90	8.35	16.23	21.02	33.80

It is observed that bran sould be solvent-extracted within several hours from the time to milling of rice. Since rice mills are scattered widely, it is difficult to collect bran from these mills in a fresh condition which is a prerequisite for manufacturing edible grade rice bran oil. Since this step is difficult, it is essential to treat bran in a suitable way so as to arrest the rise of free fatty acids of the oil in the bran. Cold storage of bran, immediately after it is "born" in the rice mill, will "kill" the lipase enzyme. That is, cold storage inhibits lipolysis on rice bran. But cold storage appears to be too costly for a relatively cheap material like rice bran. Another treatment is known as "stabilization" of rice bran which consists in heating the fresh bran. At present, no special treatment to bran is being given at rice mills because of the following reasons:

1)- There is no control over the disposal of bran

2)- Generally bran will not be retained by the rice miller

as it is taken away by the owner of paddy to feed the cattle and polutry

3)- The raw and untreated bran that is left with the miller is fetching a good price as it is and as such the miller is not willing to incur extra expenditure by stablizing the bran.

4)- Over 50% of the bran produced in the country comes from hullers and this bran is not suitable for solvent extraction and hence no treatment is warranted

5)- Most of the rice mills are smaller in capacity and the quantity of fresh bran available at a given time is also small.

It is, therefore, necessary for the government to impose restrictions on rice millers with regard to the disposal and effective treatment to the fresh bran. A number of methods have been developed by research institutes to stablize bran and this technical know-how must be disseminated and the adoption of stabilization be made feasible on the part of rice millers.

4. Selection of bran:

When one wants to rice bran for extraction purposes, he is faced with following questions :

(a) Is the bran huller or sheller type?
(b) Is the bran raw or parboiled category?
(c) Is the bran stale or fresh?
(d) Does it contain high oil, low sand & silica and low fatty acid content or vice versa ?

The third question is to be settled before purchasing. One should purchase raw or parboiled rice bran (sheller variety) which is high in oil content (Min. 16%) low in sand silica content (Max. 6%) and low in ffa (below 8%) by testing the bran at the site itself according to the "field" and "home" methods of analysis of rice bran and oil developed at Oil

Technological Research Institute, Anantapur. If a bran consignment is low in F.F.A but contains somewhat higher levels of sand and silica, from edible oil manufacture point of view, the bran is still purchasable for extraction of edible grade oil.

5. "Fines" problem during extraction:

If the bran is extracted as produced in rice mills considerable quantities of fine particles of bran also called "fines" find their way into miscella (oil-solvent solution) and settle down finally in oil. The structure of rice bran in untreated condition has also got inhibitive action on the effective extraction of oil from it eithe in batch or continuous operation. Therefore, to condition and restructure rice bran particles for facile extraction, any of the following pretreatments, namely,

(i) Pelletization or

(ii) Cooking and evaporative cooling called "Cripsing" or

(iii) "Expanding" consisting in cooling and screw-pressing should be followed.

6. Presence of wax in oil

Rice bran oil contains in varying amounts of wax depending upon varietal, processing and time factors. Although wax by itself is harmless, the cloudiness it gives to oil will not be agreeable to the aesthetic sense of the gourmet. Wax will give rise to charred gums or sludges during deep frying of oils. There are other practical disabilities (of processing, trade and tax nature) that will ariseif wax present in edible rice bran oil. It is very important that wax is removed from rice bran oil meant for edible purposes. Dewaxing of rice bran oil could be brought about by:-

(i) Setting the oil at room temperature or

(ii) rapid chilling of the oil or

(iii) centrifuging the oil or

(iv) by a combination of the above methods.

7. High refining losses:

It is experimentally obserived that even if rice bran oil has low free fatty acid content (f.f.a) (say 2%) it gives incommensurately high refining losses and loose "foots" (soapstock). Although low f.f.a oils giving incommensurately higher refining losses is also observed in other oils, this phenomenon is pronounced in the case of rice bran oil. To obviate this problem, continuous centrifugal refining might be adopted which is known to give low refining factors (ratio of refining loss in percentage divided by f.f.a. of crude oil) of one and half to two as against 3 to 5 in batch kettle process. If batch kettle process is to be followed, addition of certain chemicals like molasses, sodium silicate or pyrophosphate is reported to reduce refining losses. Treatment of rice bran oil with a class of surfactants called "hydrotropes" is also claimed to facilitate refining. Free fatty acids in high-acid oil could also be distilled off and the resulting residual oil with lower free fatty acid contents be refined with alkali as usual.

Another approach is to dewax crude rice bran oil, decolourize it and subject it to high vacum distillation now called "molecular distillation" or "physical refining" by which free fatty acids, odouriferous compounds and colour-bodies will be distilled off leaving neutral, bland and light coloured rice bran oil of edible quality.

8. Green colour of rice bran oil:

Crude rice bran oil possesses brown or green colour Green colour is mainly due to chlorophyll - like pigments. Green colour is not as easy as yellow or brown colour to remove by conventional bleaching with earth and carbon. Treatment of crude or refined oil with oxalic, citric tartaric or malic acid and subsequent bleaching with earth and caron removes green colour largely. Rice bran from parboiled rice gives oil with less pronounced greenish tinge.

9. "Brany" odour of oil:

Rice bran oil has got a peculiar haunting "brany" odour. Although the odour itself is not objectionable, its persistance makes it so. Therefore, thorough deodourization with super-heated steam is necessary for getting odourless bland edible rice bran oil.

10. High unsaponifiable matter of rice bran oil.

While other normal edible oils contain low proportions (below 1.5%) of unsaponifiable matter content, crude rice bran oil possesses high content of unsaponifiable matter (about 5 percent). Effective dewaxing and deodourization would bring down the unsaponifiable matter to acceptable levels.

11. High sand and silica content in extracted meal.

If rice bran of high sand and silica had been purchased for extraction of oil due to exigencies of situation, the resulting meal would contain higher sand silica contents. Sand & silica beyond certain levels are not desirable in meal meant for cattlefeed. Air classification, differential settling in water and sieving methods may have to be adopted to remove sand silica from meal.

12. Fluffiness or bulkiness of rice bran:

Rice bran is fluffy. It occupies large volume. Because of this storage, wagonage, transport and handling of rice bran become difficult. If rice bran could be reduced to one-third of the original.

13. Spontaneous combustion of rice bran meal.

Cases of spontaneous combustion of stored rice bran meal are known. It is mainly due to humid and hot atmosphere. High moisture content inthe meal before storage is also a contributing factor. Storage of meal with low moisture content under airy conditions will minimize hazards of spontaneous combustion.

14. Dustiness of rice bran meal.

Like all floury meterial, extracted rice bran meal poses dustiness as a problem. If the meal is blended with molasses, dustiness is obviated. Addition of molasses increases the nutrutive value of meal as well. Where this is not done, dust extractors or electrostatic precipitators have to be installed.

C H A P T E R - IV

PRODUCTIVE TECHNOLOGY OF EDIBLE RICE BRAN OIL

1. Selection of rice bran.

The quality of bran is the most important factor in the manufacturing of edible grade rice bran oil. As pointed out earlier, the bran should be fresh and its oil content should be minimum 15% for viable economics of the industry. Huller bran is unsuitable for solvent extraction since its oil content is low and total ash content is abnormally high. Efforts to beneficiate huller bran, like air-classification, sieving, etc, have proved futile. The results are shown in Tables 1 and 2.

Table 1.

Beneficiation of huller bran by air-classifier.(OTRI data)

S. No.	Yield percent		Oil content percent.		
	Beneficiated bran	Residual bran	Original bran	Beneficiated bran	Residual bran.
1.	6	94	4.9	8.0	4.5
2.	8	92	5.1	8.2	4.8

Table 2.

Sieve analysis of huller rice bran (CTRI data)

S. No.	Yield, percent Retained in Sieve 30	40	50	Passed through 50mesh	Oil content, percent Original	Retained in Sieve 30	40	50	Passed through 50mesh
-	44.9	14.2	31.1	9.7	9.9	7.0	10.1	12.2	13.4
2-	27.2	16.5	45.8	9.8	9.4	5.3	9.7	12.5	13.0
3-	10.8	16.1	42.2	30.8	6.9	4.8	5.6	7.5	8.2
4-	21.0	13.0	33.2	32.5	5.2	3.6	3.4	4.8	8.7

It is seen that huller bran is beyond beneficiation by the methods unknown so far. Bran from shellers and modern rice mills are alone fit for extraction purposes.

2. Stabilization of rice bran.

The high moisture content in the bran, particle size and lipolytic enzyme present in the bran are cumulatively responsible for the rapid rise of free fatty acid content (f.f.a.) to arrest the rapid rise of f.f.a. in rice bran, stabilization of bran is necessary before the extraction of oil for edible purposes. Various techniques of stabilization of bran are discussed below.

(a) Sundrying: The fresh bran is spread on cemented or mud plastered floors and dried in open sun for 18-20 hrs. It is claimed* that the sundried bran keeps well for about a month without much increase in f.f.a. This appears to be apparently simple but requires more thorough investigation.

(b) Cold storage. Fresh rice bran kept well at low temperature (-3.3 to 12.8°C), the rise of f.f.a. being from 2.4 to 12.7 over a period of 30 days. To adopt this technique, rooms fitted with refrigeration units have to

* S.N.Saxena Chief Chemist, Omnao Industrial Corporation Pvt.Ltd., Kanpur.

be provided. ** For transporting the bran stored in these cold storage rooms to solvent extraction plants vehicles fitted with refrigerating equipment might have to be provided.

(c) Drying with steam. Fresh bran can be dried in a rotary dryer heated by steam to about 80°C till the moisture content is reduced to below 2 percent. The dried bran stores well for over a period of 30 days.***

(d) Steaming and drying :- Rice bran is heated in a pilot plant cooker and dryer first with open steam and later by closed steam. The resultant bran is claimed to be stable well over a period of 30 days.****

(e) Steaming and expelling of rice bran:*****

(i) Steaming of bran from raw rice where the bran is stacked in layers of 0.5" to 1.0" thickness in a steam cooker for 5 to 30 min. and dried to a moisture content of 10 percent.

(ii) Raw paddy with 20 percent moisture was steamed to to 10 minutes and shade dried. This pretreated paddy is milled and bran is recovered.

(iii) Paddy was soaked in water and then steamed for 10 minutes in a steam cooker, dried and milled.

(iv) Rice bran was charged into an electrically heated revolving drum having a lid. The drum was heated while rotating keeping the vent open for about 2 minutes and later closed. Heating continued to 110 to 115° for 5 minutes.

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*S. Kumar David et al, J.Food Sci.& Tech., 2, 113(1965)
***B.Panduranga Rao et al, Ind.Oil & Soap J, 32, 203(1967)
****Technical Report (1964) of Hindustan Lever Ltd,Bombay.
*****C.S.Viraktari Nath et al, J.Food Sci., 8, 1971.

(v) Bran was fed in a screw press where in the clearance or pressure at the discharge end could be adjusted so that the temperature of emerged thin flakes ranges from 90 to 110°C.

(f) Direct flame heating.

A continuous, conveyor rice bran stablizer has been designed and fabricated by Oil Technological Research Institute, Anantapur* which could be adopted at the rice mill itself. The salient features of this unit are:
(i) a special type chula to use rice husk as fuel.
(ii) a screw type tubular conveyor to take the bran from one end to the other run by a motor of 1 H.P.
(iii) an underground flue made of brick work for the movement of hot flue gases from the chula to the chimeny encircling the pipe of the conveyour (except for the open part lengthwise at its top) embedded in the flue.

The experimental rice bran stablizer (8-16 kg. per hour capacity) set up in which rice bran is continuously conveyed forward by a screw in a flue gas heated-tube is developed. Flue gases are generated by burning agricultural wastes or any solid fuel.

(g) Fludized bed heat transfer unit.

For effective stabilization of rice bran, it is claimed that the bran is to be inactivated by contact with live steam and the inactivated bran is dried using fludized bed heat transfer system as described below briefly.

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* Work of OTRI, Anantapur under publication, See Reference 32 of Chapter 7.

The bran is fed through a hopper into the fludized bed column by means of a screw feeder. Air is heated to about 200°C by means of LPG gas burner with 'Indane' gas. The hot air is sucked by means of a blower. The heated bran is separated from hot air by mean of a cyclone separator.*

3. Recovery of oil from rice bran.

Various methods of recovering oil from rice bran will now be reviewed. The methods can broadly be devided into two (i) Pressure methods (Hyderaulic-press& screw Press) and (ii) Solvent methods (alcohol, acetone and hexane).

(i) Pressure methods.

(a) Hyderaulic-pressing of rice bran.

While oil seeds possessing oil contents between 15 to 23 percent (e.g. cotton seed) are being successfully crushed in expellers, rice bran is not. But the same rice bran under hydraulic pressing will yield 7-10 percent of oil from bran containing 17 to 20 percent oil.

It shows that static pressure is more effective than dynamic pressure and this might be due, partly, to the different manner in which the oil cells might be arranged in the bran. As rice bran is mainly a membranous layer on the starch grain rice, it is likely that the lipid droplets are aligned in layer or layers including a sheath of wax, which are pressed out more readily by super-imposed static pressure, i.e. hydraulic-pressing than by dynamic pressure (expelling or screw pressing which is mainly a process of crushing out oil distributed in space in the bulk of other oleaginous materials like oilseeds). The optimum conditions of hydraulic-pressing of rice bran are given below.:** (OTRI data)

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* Work done at Jadavpur University, Calcutta.

** S.D. Thirumala Rao, et al, OTA Bulletin, Calcutta, Annual number, December 1965.

1.	Moisture level in the bran, percent	7-12
2.	Temperature ^{o}C	100±2
3.	Pressure p.s.i. (tried with about equal effect)	78-5000
4.	Time taken-minutes	60

Oil yield from hydraulic pressing of bran are given in Table 3.

Table 3

Oil yields by hydraulic-pressing (OTRI data).

S. No.	Oil content of the bran percent	Oil yield percent
1.	17-19	7-10
2.	27-28	13-15
3.	26-27	12-14

(b) Milling of rice bran in an expeller.

Attempts have been made at the Oil Technological Research Institute, Anantapur to expel oil from rice bran using dynamic pressure in an expeller.(See Reference24, Chapter 7). By mixing well cooked rice bran of 18 percent oil content with first pressed groundnut cake of 15 percent oil content and crushing the mixture, 6 percent nett oil yield from rice bran alone has been achieved. The oil was green but could be refined to light yellow colour.

(ii) Solvent methods

(a) Solvent extraction of rice bran with alcohol.

In countries like India where natural resources of alcohol production are much greater than those of petroleums solvents, alcohol has potentialities to become popular as a solvent, if an economical process for its use is worked out. The chief advantage of alcohol in the extraction of vegetable oils is the increase of solubility of oil in alcohol with the increase in working temperature

The pilot plant data have been worked out at Central Food Technological Research Institute, Mysore for the extraction of oil from rice bran.*

When alcohol is employes as a solvent, it is necessary to reduce the moisture content of the bran to be extracted to 3 percent otherwise the alcohol gets diluted and becomes poorer as solvent. The usual distillation of the miscella to recover the solvent is not necessary in this case, because on standing the miscella at ambient temperature, the oil separates out from solvent. By this method two types of rice bran oils one with low f.f.a. and another with high f.f.a. are obtained. Low f.f.a. oil could be processed further for edible purposes. Besides, sugars and wax are also recovered as by-products in alcohol extraction method.

(b) Solvent extraction of rice bran with acetone as a Solvent.

Acetone offers as a potential solvent for extraction of oils from oleagious meterials.** Inthe case of extraction of cottonseed, acetone has specific advantages over hexane as the former dissolves not only the oil but also the pigments like gossypol, leaving behind cottonseed meal virtually free from gossypol. However, the extracted oil is highly coloured due to dissolved pigments. When acetone isemployed as a solvent for rice bran, a wax-free oil is obtained which could be easily refined by conventional methods. However, the oil obtained is coloured due to pigments like chlorophyll. The chlorophyll can be removed by pretreating the oil with acids like oxalic, malic, tartaric, citric etc., followed by conventional bleaching with earth and carbon. Acetone has a draw back. Acetone-extracted meal possesses

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* Y.K.Raghunatha Rao, et al, The Bull.C.F.T.R.I., 4, 9, 205-208 (1955)

** C.Vaccarino et al (Venetico Marina, Messina, Italy) J.Amer. Oil Chem. Soc. 30, 143 (1961)

"catty" odour in view of the formation of mesityl oxide as break down material of acetone. This odour will render the substance organoleptically unacceptable to cattle. However, efficcint desolventization technique might reduce the problem to the minimum.

Special method

Milling and solvent-extraction of brown rice.

Recent work done in U.S.A. has shown that unpolished rice, the fraction obtained during the first stage of milling paddy when hulls are removed, could be extracted with a solvent like n-hexane to recover a light coloured and low f.f.a. rice bran oil. The extracted rice is first desolventized and than remilled to obtain polished rice. The rice bran meal is reported tobe of high grade quality. However, hand ling huge quantities of unpolished rice in solvent extraction plants in India would pose practical problems.

(c) Solvent extraction of rice bran with n-hexane.

At present, the extraction of rice bran using n-hexane is being practised universally in the country on commercial scale. The specific advantages of n-hexane are:

(i) The solvent dissolves the oil thoroughly in all proportions,

(ii) since the solvent is volatile, it can easily be removed from both oil and meal.

(iii) it is non-corrosive,

(iv) it has low boiling point and the heat required for evaporation is low,

(v) it is stable.

(vi) among all the available solvents, it is the cheapest one,

(vii) it is available abundantly(at least till now),

(viii) when food grade hexane is employed for extraction purposes, the toxicity in the extracted oil is almost nil.

(ix) since hexane is immiscible with water, it could be separated easily,

(x) The chief disadvantage with hexane is its high inflammability and its non-availability in view of changing international oil situation.

Pretreatment of rice bran prior to extraction:

Rice bran is fluffy and during extraction, the fine particle size not only offers resistance to extraction and desolventization of meal, but also will give rise to "fines" problem in the oil. Rice bran has to be properly conditioned by suitable treatment before extraction. The conditioning methods are:-

(i) "Crisping"
(ii) Pelletization
(iii) "expansion".

(i) "Crisping":- Crisping is a process of evaporative cooling the material cooked at high temperature and moisture levels. The details of the technique as worked out by Southern Regional Research Laboratory, New Orleans, are given below:

The bran was fed to a stack-cooker and the temperature and moisture were raised to 95°C and 25.9 percent respectively, almost simulatenously, and cooking continued for a total period of 1 hour 12 minutes in each of 5 kettles. The bran which was discharged from the cooker at 104°C with 16 percent moisture, cooled rapidly on the trays to about 54.5°C at which the bran should be fed to slurrying conveyor. The cooking and cooling operation, besides reducing the amount of through-300-mesh fines and increasing the particle size, is stated to aid the release of oil from the bran and to impart a "crisping" or "hardening" effect to the particles. This will result in a better extractibility and reduction of the "fines" problem.

(ii) Pelletization:- The rice bran is fed to a pelletizer through a conveyor type though cooker. Bran is cooked in the trough by means of open steam to a temperature of 80-85°C for 1-2 minutes and dried to a moisture level of 10-12 percent by means of closed steam. The bran is pressed in the pelletizer over a slotted plate by means of two-rollers rotating on the plate in opposite directions. The solvent extraction of these pellets will minimise the "fines" problem.

(iii) "Expansion":- "Expansion" is a process of cooking rice bran and pressing it through a mechanical screw press also called "expander". This treatment is claimed to conglomerate (expand) rice bran particles into bigger unit and to make the material more facilitating for rate of extraction.

Machinary for solvent extraction:

There are mainly two types of solvent extraction plants in vogue now. They are (1) batch type and (2) ntinuous type. Both these types are being manufactured indigenously though some plants were imported in initial stages of the industry. Batch type plants are compact, simple in operation, low-priced and easily accessible to small and medium industrialists. Continuous plants are elaborate, sophesticated in mechanism, high priced and accessible to big industrialists only. Table 4 gives oil contents in the bran and deoiled bran obtained from different plants.

Brief process of extraction:

The stabilized and pretreated bran is charged into the extractor. After the extraction is complete, the miscella is sent for distillation to recover the solvent and oil. The solvent thus recovered is reused. The oil is further subjected to desolventization to remove the last traces of solvent.

Table 4.

Oil yields in batch and continuous plants.

S. No.	Material	Batch		Continuous	
		Range percent	Average percent	Range percent	Average percent
1.	Rice bran				
(a)	Oil content before extraction.	12.7-16.5	14.6	15.0-17.5	16.7
(b)	Oil content after extration	1.0-2.0	1.5	0.7-0.8	0.75
(c)	Oil yield	11.6-15.0	13.5	13.0-17.5	15.2
(d)	Meal yield	85.0	85.0	83.0	83.0

The extracted meal is thoroughly desolventized using higher temperature and vacuum. For the manufacture of edible grade rice bran oil, it is necessary to employ food grade hexane whose specifications are given in Table 5.

High purity hexane under the names as "hydrogenated hexane", "Dual refined hexane" etc, are being made available to the industry for solvent extraction purposes, especially where the end products are meant for edible purposes.

4. Dewaxing of rice bran oil.

The commercial rice bran oil obtained from the solvent extraction of rice bran contains about 1-7 percent wax. This has to be removed by any of the following methods or a combination of them before the oil is processed further.

(i) Gravity settling.

The extracted rice bran oil is allowed to settle in large conical shaped tanks for a few days at ambient temperature. The solid wax settles at the bottom due to gravity as it is slightly denser than oil leaving behind clear oil on the top. The oil layer is easily syphoned out.

Table 5.

Tentative specifications for "food grade" hexane for use in defatting oleagrinous materials (WHO/FAO specification).

S.No.	Property or component	Hexane Min.	Max.
1.	Paraffins (including Naphthenes) percent by 1.v	99.5	-
2.	Olefine percent by v.	-	0.1
3.	Benzene percent by 1.v	-	0.5
4.	Other aromatics percent by 1.v	-	0.5
5.	Specific gravity API + at 60°F	76.0	-
	Distillation		
1.	Initial B.P. °F	150.0	-
2.	Dry point	-	158.0
3.	Temperature range of final 10 percent °F.	-	3.0
4.	Evaporation residue mg/100ml	-	0.05
5.	Sulphur ppm	-	50.0
6.	Lead ppm	-	0.0
7.	Tricresyl phosphate ppm	-	0.0
8.	Colour Saybolt	30.0	-
9.	Doctor test	Negative	-
10.	Copper corrosion (all tests)	Negative	-
11.	Reaction of distillation residue (methyl orange) 1.v = liquid volume	Neutral	-

(ii) Chilling.

Rice bran oil in suitable containers is kept in cold storage whose temperature is maintained at 10°C. The solidified wax settles at the bottom and the clear oil is removed either by syphoning or by centrifugation.

(iii) Centrifuging.

The solvent extracted rice bran oil can be directly centrifuged to remove wax. Chilled oil can be centrifuged to remove wax.

(5) Refining of rice bran oil

Refining of dewaxed rice bran oil comprises of the following steps:

i) Degumming
ii) Alkali neutralization
iii) Bleaching
iv) Deodourization.

(i) Degumming.

Gums which are present in the oil have to be removed before alkali neutralization to prevent high refining losses as gums form emulsions with neutral oil and lowers the quality of the oil.

The dewaxed rice bran oil is degummed by adding 3 to 4 percent water at about 80°C, stirred well and allowed to settle overnight. The gums get hydrated and settle at the bottom. The degummed oil is either syphoned out or centrifuged to separate the gums. The hydration of gums could also be effected by steaming the oil for some time. This also is optional as neutralization could be carried out even without degumming.

(ii) Alkali neutralization.

The degummed rice bran oil is subjected to alkali neutralization for removing free fatty acids, colour and other impurities. This can be done either in a batch process or in a continuous system. In either method, the amount of alkali required for neutralization of oil is calculated on the basis of free fatty acid content in the oil.

(a) Batch process:-

Rice bran oil is charged into conical shaped vessel provided with steam jacket and open steam coil to heat the oil. It is also provided with an variable speed stirrer. The calculated amount of alkali is slowly added to the oil which was preheated to 70°C. After the addition of alkali, the stirring speed was reduced and the oil is maintained at that temperature for another 10 to 20 minutes, than a "break" is observed. At this stage stirring is stopped and 1 percent brine solution sprayed over the oil and allowed to settle for overnight. (the neutralized oil could be centrifuged directly to separat soap immediately, after the alkali addition). The soap stock that is formed settled at the bottom is drained off. The clear oil is washed with hot water to remove traces of soap. The washed oil is then dried.

From studies conducted at Oil Technological Research Institute, Anantapur, it is seen that the alkali refining of rice bran oil is usually met with incommensurately high refining losses. To prevent these looses some additives were tried before the addition of alkali or during neutralization step. The additives and their efficacy in reducing the refining losses are given in Table 6.

As seen from the Table 6, Jaggery and molasses are effective in the reduction of refining losses. Moreover, they are cheap and easily available and hence these two additives are recommended for the reduction of high refining losses, especially, in batch process.

(b) Continous process.

In this process, strong caustic soda lye and oil are passed by adjustable proportioning pumps through a continuous mixes emulsifier and a heater where the mixture was heated to about 60°C. for the 'break'. Then

it is allowed to pass through centrifugal separators of the "Sharples super centrifuge" or "De-Laval" centrifugal separators for the separation of neutralized oil and soap stock. The total contact period of oil and alkali is only 3 to 4 minutes, thus minimising the risk of over-saponification inspite of excess of caustic used. The soap stock is discharged through the sludge outlets from centrifuges while the neutralised oil, containing a trace of soap and moisture in suspension, is pumped to a wash tank, where it is mixed with 10-15 percent hot water of 75 to 80°C and passed through a secondary centrifuge, from which a practically soapfree neutral oil is obtained.

Table 6.

Reduction of refining losses due to the additives.(CFRI data)

S.No.	Additives used	Reduction of refining losses percent from	To	Percentage reduction.
1.	Sodium pyrophosphate	62	36	42
		51	24	53 } 46 (av)
		56	32	43
2.	Jaggery	62	42	32
		51	27	47 } 44 "
		56	27	52
3.	Molasses	62	32	48
		62	37	40 } 44 "
4.	Sodium silicate	62	32	48
		51	31	39 } 37"
		56	42	25

(c) Miscella Refining.

In this method, alkali neutralization of oil takes place when the oil is in the miscella form.

A vessel fitted with a mixer is fed at a steady rate, with crude oil, hexane, alcohol and caustic. The mixture overflows into a continuous decanter where it forms three well separated layers: refined oil insolution with hexaneconstitutes the upper layer, the soap in solution in alcohol, in lower layer, the gums and all the impurities form the intermediary layer.

A still eliminates the hexane from the refined oil, the lower layer is treated with sulphuric acid so as to obtain fatty acids which are s tripped off from alcohol, in a still combined with an alcohol rectification coloumn, and a third evaporator eliminates the solvents from the impurities.

Advantages of miscella refining.

1. Dilute caustic soda solution can be used satisfactorily.
2. The wide specific gravity differential between the lye and the oil-hexane solutions increases the efficiency of the centrifugal separation.
3. The soap stock is extremely low in neutral oil, i.e.,the refining loss is at a minimum.
4. The colour of the oil is superior to that of obtained by other methods.

Some disadvantages.

1. All equipment must be totally enclosed and explosion-proof. This increases the investment considerably.
2. Equipment must be carefully maintained and operated to avoid excessive solvent losses.

(d) Distillation and refining.

High acid rice bran oil can be vacuum-distilled to remove excessive fatty acids and the residue with

low f.f.a. could be alkali neutralized by any of the afo-resaid methods. Refining data on such and oil are given in Reference 22 of Chapter 7.

(e) Molecular distillation

Oils with low f.f.a. could be distilled under high vacuum called "molecular" distillation. It is a case of physical refining. Free fatty acids, odouriferous principles and colour bodies are distilled off leaving behind neutral, blan and light coloured oil of edible quality. This method is followed for olive oil in Europe. But, for rice bran oil, it appears to be too costly.

(f) "Hydrotrope" refining.

A British concern has claimed that incorporation of a class of surfactants like sodium xylenesulphonate popularly known as "hydrotropes" during alkali-refining will remove acidity from high acid oils like rice bran oil. But the method does not seem to be followed commercially.

(iii) Bleaching:

Bleaching is an important step in the refining of vegetable oils as it removes undesirable colouring matters The natural colouring matters present in rice bran oil are carotenes, xanthophylls, chlorophylls etc.

Bleaching is carried out in the industry by absorption of the colouring matters by bleaching earths and activated carbons.

The oil is taken in neutralizer-cum-bleacher provided with steam jacket and closed steam coils. The oil is heated to 80°C. under vacuum of 28" of mercury. Calculated quantities of activated earth and carbon are sucked in deep into the oil and stirred well. The vacuum and temperature are maintained for about 1 hour

during which time the colour of the oil would have been bleached by the absorbents. The oil is filtered through a filterpress when clear oil comes out leaving behind the earth and carbon in the filter-press.

This type of conventional bleaching oils is not adequate for rice bran oil since it contains greenish tinge owing to chlorophylls and xanthophylls present in rice bran. Therefore, rice bran oil requires a special treatment which has to be incorporated in the conventional method of bleaching mentioned above. The special treatment is described below:-

The oil is pretreated with 3 to 5 percent either oxalic, citric malic or tartaric acids in aqueous solution for 1/2 hour at ambient temperature with good stirring. The temperature of the mixture is raised to 80-85°C. to break the emulsion and allowed to settle at that temperature. The acid layer is drained off from the bottom and the oil is washed with hot water till it is free from acid. (See References 9 & 20 in Chapter 7)

Later, the oil may be bleached by the conventional method. The refined and bleached rice bran oil may be incorporated in a mix meant for the manufacture of hydrogenated oil (venaspati) to give solid edible fat.

(iv) Deodourization:

Bleached rice bran oil still contains odour, and colour peculiar to itself. This requires deodourization.

Deodourization is a process for removing substances which impart undesirable odour and taste to the oil. Most fats and oil either because of their natural flavour or

changes during storage and processing, need as part of their refining treatment, a final deodourization to give them a bland or a mild flavour which is considered essential for their successful use in the manufacture of edible fatty products. In the rice bran oil, a characteristic 'brany' odour is present which is unpleasent because of its presestence.

Therefore, it is all the more necessary to deodourize the solvent extracted rice bran oil after alkali-neutralization and bleaching.

A deodourizer is a cylindrical vessel-shallow dished top and bottom. The height is usually twice the diameter, and the working capacity is more than half the volume, thus providing ample headspace for expansion of the charge when heated up, and for ebullition and splashing. An amplydimensioned vapour-off-take at the top connects the vessel with the vacum system through an oil-catcher to collect certain particles. The vessel is fitted with an internal heating coil and when temperature of oil has reached 80-90°C., open superheated steam is blown in through an inlet at the bottom. For satisfactory deodourization, a vacuum of atleast 29" of mercury should be employed, since the volatility of the products to be removed is directly dependant on this factor. During the deodourization process which may last for several hours, the temperature of the oil should be maintained to about 0-18°C. After deodourization, the oil is cooled under vacuum to about 80°C., after which it is run into a storage tank.

The deodourized rice bran oil thus obtained and conforming to IS specification for rice bran oil (IS: 3448-1968) is fit for edible purposes either as a direct cooking oil or as a saled oil.

A diagramatic flow sheet (Blue print) including typical steps, for producing edible rice bran oil is also given in the accompanying Figure-1.

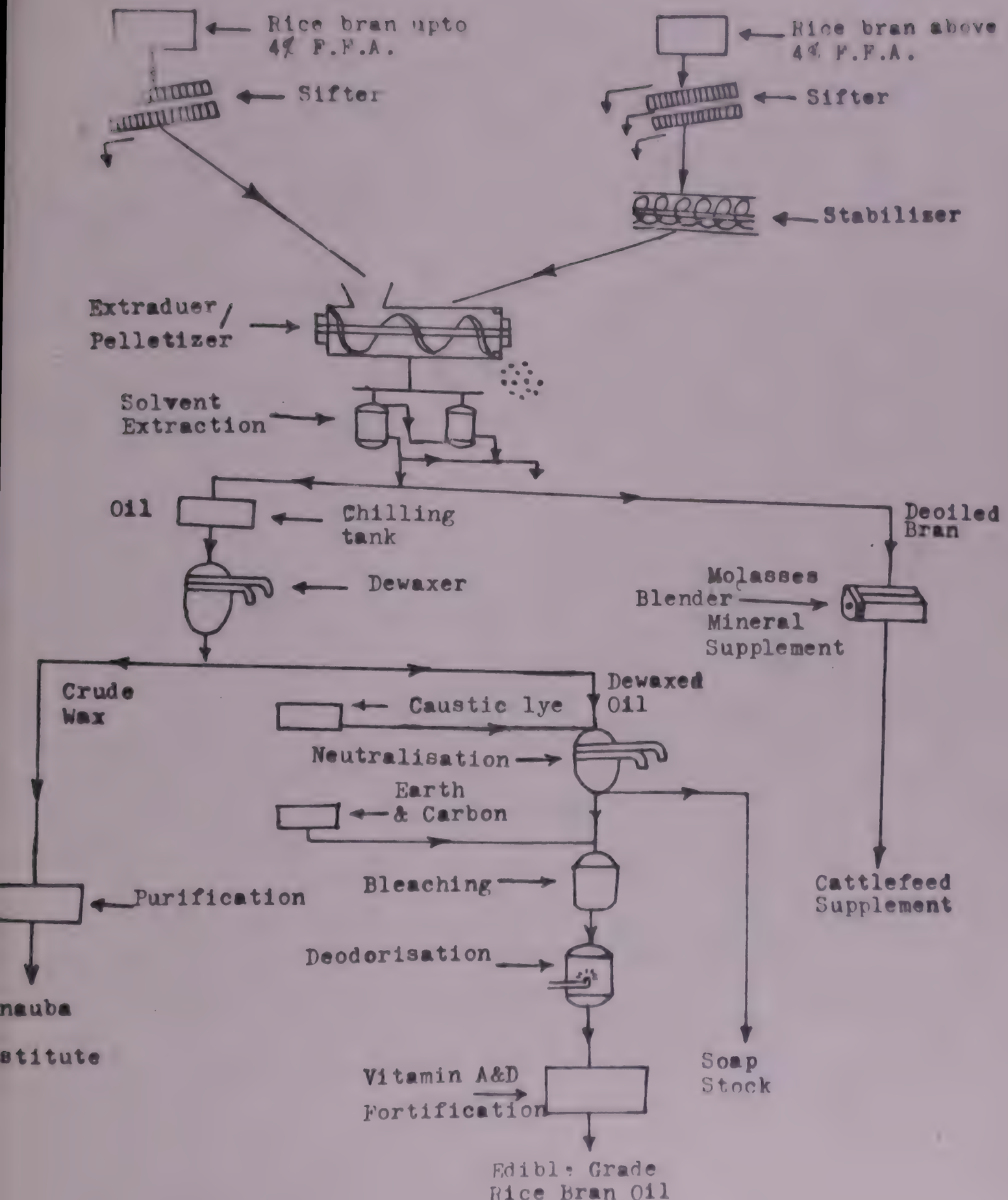
Rice bran upto 4% F.F.A.
Rice bran above 4% F.F.A.
Sifter
Sifter
Stabiliser
Extraduer / Pelletizer
Solvent Extraction
Oil
Chilling tank
Deoiled Bran
Dewaxer
Molasses Blender
Mineral Supplement
Crude Wax
Dewaxed Oil
Caustic lye
Neutralisation
Earth & Carbon
Bleaching
Purification
Cattlefeed Supplement
Deodorisation
nauba
stitute
Soap Stock
Vitamin A&D Fortification
Edible Grade Rice Bran Oil

FIGURE 1

C H A P T E R - V

SCHEMES FOR THE PRODUCTION OF EDIBLE RICE BRAN OIL.

Scheme-I, furnishes the economics of production of edible rice bran oil and its by-products, viz. Cattle feed, Refined Wax and Soap stock. Scheme -II, furnishes the economics of production of crude rice bran oil of low f.f.a. that can be refined by known methods.

The Scheme-I I for production of edible rice bran oil is prepared for a processing capacity of 15 tonnes of Rice Bran per day. It will be seen from this scheme that the returns per annum will be 36 percent of the capital investment of Rs.35.67 Lakhs. This is a decent profit. From this, it is surmised that even with a processing capacity of 10 tonnes of rice bran per day there could still be a good margin of profit. Therefore, economically viable plants can be set up even with a capacity to process 10 tonnes of rice bran per day for production of edible rice bran oil. Such a unit can be set up in the proximity to rice mills situated within a radium of about 100 kilometers to facilitate quick transport of rice bran to the solvent extraction plant before the rice bran developes excessive acidity.

It is possible that during certain periods, there will be availibility of bran exceeding the plant's capacity to process. At other Periods supply of bran may fall short of the plant's capacity. It is, therefore, necessary to collect whatever quantity of fresh bran is available during surplus periods to compensate for short supply during the lean periods.

Such of the fresh bran that is collected can be straight away fed to the solvent extraction plant after passing through the extruder (pelletizer).

The fresh bran in excess of the plant's capacity will have to be immediately stabilized to prevent its deterioration. Stabilizers, therefore, have been provided in the scheme.

By extracting fresh bran or stabilized bran, crude rice bran oil with low f.f.a. can be obtained. The oil which contains wax has to be dewaxed by chilling and or centrifuging to separate the wax. Here the wax is a valuable by-product and it can be further purified to produce refined grade wax which fetches good price and serves as a substitute for imported carnauba wax thereby saving foreing exchange considerably.

The dewaxed rice bran oil is refined in a continuous refining plant, bleached, deodourized and fortified with vitamins A & D to yield high grade edible rice bran oil which has excellent nutritive properties. This oil can fetch the same price as ground nut oil. It may even go at a higher price.

Crude rice bran oil with its dark colour, wax content, peculiar odour and high f.f.a. which results in heavy refining losses uneconomical to industry, is used for industrial purposes, mostly for soaps. Rice bran with its high potential of oil and which can be utilized to produce high grade edible oil by scientific methods has not so far been utilized as a source of edible oil, If all the rice bran produced in our country is subjected through

scientific exploitation by modern techniques on the lines of the present scheme, the edible oil shortage in the country would become a thing of the past.

The by-product, soap stock, can be utilized in the manufacture of soap. The extracted bran with its enhanced protein content is fortified with mineral supplements and made palatable by blending it with molasses.

Scheme II is meant for solvent extraction of fresh rice bran as soon as it is produced in rice mills. The scheme is prepared for smallest and economically viable unit with a capacity to process 2 tonnes of rice bran per day of 24 hours. Its capital investment is Rs.5.83 lakhs and profit about 21 percent. This plant can be set up as an adjunct to a rice mill or also as an independent unit within the proximity of a ring of rice mills.

Fresh rice bran as soon as it is produced in processed in solvent extraction plant to give curde rice bran oil of low f.f.a. which can be easily refined to yield edible rice bran oil. No stabilizers have been provided in the scheme since the scheme envisages extraction of oil from the bran in fresh condition thus obviating the need for ftabilization of the bran. There is excellent scope for starting this 'micro' type solvent extraction plants in all rice producing centres for extraction of rice bran oil. One of the suppliers of solvent extraction plants listed in Chapter I (Servotech) has recently offered to sup ly such plants. (The Hindu dated September 28, 1974)

Scheme I for the Production of Edible Rice Bran Oil.

	Rs	P
1. Land :- 2 acre Rs.20,000 per acre	40,000	

2.	Buildings:- Godowns, sheds, garrages well, overhead tank, water pound compound wall and other civil works	6,00,000	6,40,000
3.	Plant and machinery.		
	i) Rice bran sifter for separation of broken rice and husk, including motor.	25,000	
	ii) Rice bran stabilizers 3 Nos.(including motors).	1,00,000	
	iii) Solvent Extraction Plant complete with feed conveyor, solvent storage tanks, motors, electrical accessories, light fittings, cable and wiring, conduits, sight glasses, circulating pumps, ejectors, thermometers, pressure and vacuum gauges, valves, steam traps, piping, control panel etc... ...	8,00,000	
	iv) Filter presses with pump and motor.	25,000	
	v) Chilling plant... ...	1,00,000	
	vi)Continuous refining plant including dewaxing, neutralising, bleaching and de-odourising units...	3,00,000	
	vii) Stainless steel kettle with conical bottom with openings for feeding and discharge and with stirring arrangement...	40,000	

viii) Blender for mixing deoiled rice bran with molasses and mineral suppliments	45,000	
ix) Boiler with accessories and steam distribution... ...	1,20,000	
x) Cooling towers for exit water from the plant and pumping installations...	50,000	
xi) Bulk storage tanks for oil.	60,000	
xii)Electrical installations.	1,25,000	
xiii) Heat insulations.	20,000	
xiv) Laboratory equipment...	50,000	
xv) Fire fighting equipment.	10,000	
xvi) Workshop equipment and tools.	50,000	
xvii) Furniture and office equipments...	15,000	
xviii) Barrels, weighing machines, tins etc...	30,000	
xix) Packing, forwarding and transportation to site... ...	75,000	
xx) Lorry.	80,000	
xxi) Provision for CST etc.	75,000	
xxii)Erection materials, Erection and commissioning.	2,50,000	
	24,70,000	24,70,000
Working capital:For one Month		
i) Raw materials	3,92,500	
ii) Salaries and wages	24,500	
iii) Miscellaneous	39,700	
	35,66,700	4,56,700
Total Capital investment	or	

6. Estimates of production

Cost Per annum.

		Rs	Rs
i)	Rice bran 4500 tonnes @Rs.930/- per tonne...	41,85,000	
ii)	Solvent 85,000 litres	2,00,000	
iii)	Coal and Fuel	2,00,000	
iv)	Filter cloth, caustic soda, bleaching earth & vitamins A & D. for fortification, molasses (30 tonnes) and minerals for nitric acid (30 tonnes) for bleaching of wax and other materials...	1,25,000	

7. Salaries and wages.

a)	Technologist-cum-General Manager.		Rs. 1000/-p.m.
b)	Maintenance Engineer		800/- "
c)	Shift Chemists - 3 Nos.	(each)	600/- "
d)	Shift Foremen - 3 Nos.	"	600/- "
e)	Office Manager - 1 No.		600/- "
f)	Manager (Sales and purchases)		500/- "
g)	Machanics -12 nos.	(each)	400/- "
h)	Skilled workers - 9 Nos.	(per day each)	10/- "
i)	Unskilled workers -30 Nos.	"	5/- "
j)	Electricians - 3 Nos.	(each)	300/- "
k)	Boiler Operators -3 Nos.	"	400/- "
l)	Refrigeration Mechanic -1 No		400/- "
m)	Accountant - 1 No.		400/- "
n)	Storekeeper - 1 No.		400/- "
o)	Typist - 1 No.		400/- "
p)	Clerk - 1 No.		300/- "
q)	Lab. Attenders - 3 Nos	(each)	250/- "
r)	Drivers - 3 Nos.		125/- "
s)	Cleaners - 3 Nos.		250/- "
t)	Office Attenders 3 Nos.		125/- "
u)	Watchmen - 2 Nos.		
		Total	Rs. 24,525/- p.m. or Rs. 24,500/- p.m.

Rs. 24,500x12 = Rs. 2,94,000.00

III	Power requirements	Rs	Rs
	i) 1000 k.w.h. per day	60,000	
	ii) Cess @ Rs6/- per tonne of oil and excise duty at Rs 100/-per tonne of oil, on 624 tonnes	66,200	
	iii) Repairs, renewals, handling, insurance, maintenance, licences, travelling, conveying, printing and stationery etc.	2,50,000	
	iv) Diesel for lorry and maintenance.	1,00,000	4,76,200
IV	i) Interest at 12% per annum	4,28,000	
	ii) Depreciation at 10% on plant and machinery and 5% on buildings and civil works.	2,77,000	7,05,000
	Total manufacturing cost per annum.	61,85,200 or 61,86,000	
V.	Sales returns per annum		
	i) Edible rice bran oil as Rs 8500/- per tonne 624 tonnes.	53,04,000	
	ii) Cattle feed at Rs 500/- per tonne 3800 tonnes	19,00,000	
	iii) Refined rice bran wax at Rs 10,000/- per tonne 14 tonnes.	1,40,000	
	iv) Soap stock at Rs 2000/- per tonne 70 tonnes	1,40,000	
		74,84,000	

VI Profit per annum = Rs.12,98,000 (36.3%)

Scheme II - Small Scale Scheme for Production of Low Free Fatty Acid Rice Bran Oil.

1)	Land : One acre	20,000	
2)	Buildings including overhead tank...	1,00,000	1,20,000
3)	Plant and machinery		
	i) Solvent Extraction plant Batch type including pelletizer 2 tonne per day.	2,50,000	
	ii) Boiler	30,000	
	iii) Pump-set, storage tanks, barrels, tins & weighing equipment.	30,000	
	iv) Laboratory apparatus, workshop equipment and tools.	15,000	
	v) Furniture and office equipment.	5,000	
vi)	Power, steam, water lines, erection materials, foundation erection and commissioning.	70,000	4,00,000
4.	Working Capital for one month		
	i) Raw materials	51,500	
	ii) Salaries and wages	8,000	
	iii) Miscellaneous	3,500	63,000
5.	Total capital invest-ment	5,83,000	
6.	Production cost per annum		
	i) Raw materials.		
	Rice bran 600 tonnes @ Rs 930/- per tonne	5,58,000	
	ii) Solvent 18000 litres @ Rs 2.25 per litre	40,500	
	iii) Coal	18,000	
	iv) Lab. Chemicals	1,500	6,18,000

II. Salaries and wages.

i)	Chief Chemist-cum-General Manager		800/-p.m.
ii)	Chemist - 1 No.		500/- "
iii)	U.D. Clerk & Storekeeper 1 No		300/- "
iv)	Typist -1 No.		300/- "
v)	Shift foreman - 3 Nos.	each	400/- "
vi)	Boiler attenders - 3 Nos.	"	300/- "
vii)	Skilled worker - 6 Nos.	per day "	10/- "
viii)	Unskilled workers -12 Nos	" " "	6/- "
ix)	Watchemen -2 Nos.	each	100/- "
x)	Lab- Attender -1 No.		150/- "
xi)	Peons - 2 Nos.	each	150/- "

7,950|-pm. x12=95,400

III - Power requirements.

i) Power	10,000	
ii) Repairs, renewals, insurance travelling, stationery, printing etc...	18,000	
iii) Excise duty @ Rs.100/-per tonne of oil	9,600	
iv) Cess @ Rs 6/- per tonne of oil	600	38,200
IV i) Depreciation @ 10% on machinery and 5% on building.	45,000	
ii) Interest at 12% on the capital investment.	70,000	1,15,000
Total production cost	8,66,600 or Rs 8,67,000	

. Returns

i) Rice bran oil 96 tonnes @ Rs 7,500/- per tonne	7,20,000
ii) Deoiled bran 500 tonnes at Rs 450/- per tonne	2,25,000
	9,45,000
Profit.....	Rs 78,000
profit without taking depreciation into account	Rs 1,23,000 (21.1%)

Some Practical considerations/a postcript.

The crux of the problem in the case of production of edible rice bran oil is the availability of rice bran of low free fatty acid content (f.f.a.) This aspect and related matters are discussed below from a practical point of view.

i) Rice bran as soon as it is produced at the rice mills have a very low f.f.a. This rice bran can be directly fed to the solvent extraction plant to give crude oil of low f.f.a.

ii) Where the production of rice bran at rice mills in the vicinity exceeds the capacity of the solvent extraction plant, the excess rice bran has to be stablized immediately after it is produced to prevent the development of high f.f.a in the bran. For this purpose, either the rice mills or the solvent extraction plant will have to provide themselves with the necessary equipment. As the stabilizer developed at the oil Technological Research Institute does not require steam but only rice husk or other solid fuel, it can be conveniently set up at rice mills themselves to stabilize bran as and when it is produced. Other methods of stabilization described in Chapter 4 require steam, electricity and conventional fuels like furnace oil or solid fuel and therefore are not ideal from economics and technology points of view.

If the group of mills supplying rice bran to the solvent extraction plant find it inconvenient to set up equipment for stabilization at each mill, it would be desirable for the solvent extraction plant to have the stabilization equipment. In either case, it will be necessary for the solvent extraction plant to equip itself with a lorry for transportation of rice bran to plant site. Railway transport is inadvisable in the case of rice bran .

iii) During the periods when there is short supply of bran to the plant, the plant can keep itself working drawing upon stocks of bran already stabilized earlier during periods of surplus supplies.

Rise of f.f.a. in rice bran can also be kept under control by storing the fresh bran at low temperatures. This can be done either at the rice mills or at the plant site. Even if a chilling plant is set up at each rice mill, it will still be necessary to have a chilling plant at the plant site to store the bran till such time it is consumed. The cost of operation of the refrigeration plants is likely to make this method uneconomical. But, in view of the effectiveness of this method (it gives more pristine oil than thermo-stabilized bran), it cann't be altogether ruled out when emergency of the nation demands supply of the vital food article like edible oil.

Raw rice bran under transport to solvent extraction plants should be treated as a perishable commodity and be given priority by providing refrigerated wagons in the place of usual steel wagons. Sri A P Shinde, Union Minister of State for Agriculture while adressing the seminar on marketing of perishable foods has asked the Institute of Marketing an Management to develop the cold storage industry to meet the rising demands in the country. (The Hindu dated October 19, [illegible]

When the plant is able to get 15 tonnes fresh bran every day, the fresh bran can be directly fed to the pelletizer and then to the Solvent extraction plant. There may be times when the plant may not be able to get fresh bran not only bran with some developed f.f.a. In such cases, the bran will have to be immediately stabilized to prevent further deterioration and stored in a separate godown for future use. Depending upon the extent of f.f.a. At the time of receipt at the plant site, it can be decided whether it is economical to produce potentially edible grade or technical rice bran oil.

If the rice mills are situated at a distance of 100Km. it would perhaps be desirable that such mills should equip themselves with equipment to stabilize the bran as soon as it is produced at such mills. Such mills can always demand a higher price for stabilized fresh bran. The higher price so realised will more than compensate the investment on the stabilization equipment. The mills can use the paddy husk produced by them as fuel for the stabilizers. Scheme I (15 tonnes) could be implemented by installing a string of such plant complexes in the east coast of India starting from Calcutta and coming down to Orissa, Andhra Pradesh, Tamilnadu and then going up to West coastupto North Canara Coast. In selected centres in Madhya Pradesh, Maharashtra, Punjab, Haryana, Bihar and Assam some units could be set up. If 150 such units are set up, about 0.10 million tonnes of edible rice bran oil currently valued at Rs 80 crores could be produced in a year. If this is done on war footing, there then would be no necessity to import soybean oil from U S A or sunflower oil from U S S R The recurring amount now spent every year in importing oils would thus suffice to solve "oil famine" once and for all. Scheme II (2 tonnes) can be implemented virtually in every small town in coastal Andhra Pradesh where fresh sheller type rice bran upto 3 to 4 tonnes will be available daily from clusters of rice mills

scattered within municipal or panchayat limits of those towns. Such small plants are actually offered by reputed solvent extraction plant suppliers like Servotech, Bombay, Therefore, this proposition is eminently practical and not utopian.

C H A P T E R - VI

BYPRODUCTS.

Deoiled bran, also called "rice bran extractions" soap stock, wax and spent e rth are the by-products of the rice bran oil industry.

Deoiled bran:

Deoiled rice bran forms 80 percent of the bran processed. At this rate, the estimated production of deoiled bran is to the tune of several lakhs tonnes annually in the country. Of this, nearly 80 percent of the production is being exported to countries like Poland, Hungary, Czechoslovakia etc.

The deoiled bran forms a good cattle feed. It may either be used as such or admixed with 3 percent molasses. The molasses-admixed bran will have an increased nutritive value.

It is reported that raw rice bran causes loose bowls in cattle, especially when bran is somewhat stale. The solvent extraction of rice bran, not only increases the keeping quality of the bran, but also increases the nutritive value by correspondingly increasing the protein content. Thus the deoiled bran is as good as cattle and poultry feed. The protein content in the deoiled rice bran varies from 14 to 16 percent lysine, the two essential aminoacids. The deoiled rice bran forms 20-40 percent in the cattle feed mixture and 18-20 percent in poultry feed mixtures. The requirements for solvent extracted rice bran as live-stock feed is given under the Emergency, Indian Standards Specifications IS : 3593E-1966 and given in Table 1.

Deoiled rice bran can also be used as a fertilizer. It contains 2-2.5 percent nitrogen and 1-2 percent phosphorus. It is a suitable organic fertilizer for fruits, flowers and tobacco crop.

Table 1

Requirements for solvent extracted rice bran as livestock feed
IS: 3593E-1966

S.No.	Characteristics	Requirement Grade 1	Grade 2
1.	Moisture percent by weight, Max.	10	10
2.	Crude protein (nitrogen x 6.25) percent by weight, Min.	15	1.
3.	Crude fat or ether extract, percent by weight, Max.	1.0	1.5
4.	Crude fibre, percent by weight, Max	8	12
5.	Total ash, percent by weight, Max.	8	12
6.	Acid insoluble ash, percent by weight, Max.	2.0	3.0

Deoiled rice bran with low sand and silica and fibre has a potential use as an ingredient for blending with wheat flour for taking darn break of low cost and high nutritive value. It can also be used for biscuit manufacture for use in vitamin B deficiency cases. In some special cases deoiled rice bran is used as an effective larvicide.

Removal of sand & silica from rice bran:

The export specification for deoiled bran prescribes, a maximum of 8 percent sand and silica content. Bran samples having more sand and silica often get rejected. However, because of poor narvesting practices, antiquated milling methods and unwholesome marketing procedures, bran with higher percentage of sand & silicia occurs usually. Removal of sand & silica from hese brans was tried adopting air classification and differential settling methods (see Reference 31 of Chapter 7. Differential method, especially is suitable for feeding the cattle with high sand and silica bran.

Recovery of vitamins and sugars from rice bran:

Rice bran is a source of vitamins, sugars and starch as seen in Table 2 and 3.

Table 2.

Vitamins in rice bran

S. No.	Name of Vitamin	Vitamin content ug/gm.
1.	Thiamine	27.9
2.	Nicotinic acid	408.6
3.	Pantothenic acid	71.3
4.	Pyridoxine	32.1
5.	Riboflavin	2.4
6.	Biotin	00.47
7.	Tocopherols	30.0

Table 3

Sugars in rice bran

S. No.	Sugars in syrup	percent
1.	Pentose	0.17
2.	Sucrose, d-glucose and d-fructose	2.16-3.0

The vitamins and sugars can be recovered from rice bran by extracting with water and concentrating the extract. Where sand and silica and hull contents in consignments of extracted bran are high and the marketing of it becomes problem.

still such a bran could be put to better use by extracting water soluble vitamin B complex and sugars. Work under progress at the Oil Technological Research Institute has shown that stored rice bran has got high content (upto 4 percent) of free glycerol in it. It is well known that glycerol is a food article and has a distinction of being named as the "most used liquid after water" The extract containing sugars and vitamins could be used in tonic food and pharmaceutical industries.

Another approach is to hydrolyse the bran with mineral acid to convert starch in the bran to sugar.

Soap Stock:

The other important byproduct of edible grade rice bran oil Industry is the soap stock. The soapstock and wash waters are obtained during the process of alkali neutralization of raw oil. Soap stock contains a fairly high proportion of fatty matter the actual amounts varying according to the free fatty acid contents of the oil and the strength of the caustic alkali used in the neutralization process. It usually varies from 20-25 percent, the remainder chiefly being water. Almost all the soapstock produced in the country is used for soap making purposes. The soap stock from the rice bran oil industry is sold to soap factories either as produced or grained according to the mode of transport facilities available.

The soap stock is split with mineral acid such as sulphuric acid to produce what is commonly known as "acid oils" which are used in soap industry or for distilling purer "tailor-made" fatty acids.

Wax:

The solvent-extracted rice bran oil contains wax which may be called a "by-product of a by-product". The amount of wax ectracted depends upon the factors like temperature of extraction, the nature of the solvent used and the variety of

the bran. In India, many solvent extraction plants are [illegible] in rice bran extraction and sizable amount of crude wax will be available.

The wax is insoluble in oil at low temperature and settles down as a sludge which can be separated either by decantation or centrifuging. The somposition of the crude rice bran wax is given in Table 4.

Table 4

Composition of crude rice bran wax (CTRI data)

S. No.	Constituents	percent Range
1.	Oil	15-25
2.	True wax	45-55
3.	Non-lipids	
	(i) moisture & volatilo matter	15-25
	(ii) soluble mineral matter	1.5-2-2
	(iii) sand and silica	1.5-3.5

The Crude wax is extracted with n-hexane in hot condition to obtain true wax. The miscella is concentrated and cooled. To this, cold acetone is added to precipitate the true wax. The precipitated wax is filtered and washed with cold acetone to remove traces of oil. The wax is dried in hot air . The characteristics of true wax separated from crude wax are given in Table 5.

Table 5.

Characteristics of true wax (CFRI data)

S.No.	Characteristics	Range.
1.	Saponification value	85 - 88
2.	Iodine value (Wijs)	8 - 10
3.	F.F.A.	2 - 7
4.	Non-saponifiable matter, percent	44 - 60
5.	Ash content, percent	0.05 - 0.3
6.	Melting point °C.	80 - 82

The quality of the true wax can further be improved by bleaching with nitric acid. This method has been developed by the Oil Technological Research Institute, Anantapur (See Reference 23 & 26 of Chapter 7). Rice bran wax can find use in the manufacture of polishers stencils, food preservatives etc. and can partly substitute the imported carnauba wax which is still the "queen of waxes".*

Spent earths:

The spend earths, obtained during bleaching of rice bran oil, contains 25-50 percent oil depending upon the mode of recovery of oil from spent earths during filtration of bleached oil. Methods have been evolved at Oil Technological Research Institute, Anantapur** to recover the residual oil from these spent earths. About 80-100 percent of oil could be recovered by these methods.

* Chapter ":Plant Waxes" Page 241 by Sheila Hamilton and Richard J. Hamilton in "Topics in Lipid Chemistry" Vol.3Ed.b F D Gunstone Elk Science London 1972

** "Recovery of oil from spent earths" K Venkateswara Rao et al Oil & Oilseeds Journal-18 No.10,pp 12-14,April 1966

Rice Hulls:

Though rice hulls do not form a by-product of rice bran oil industry in the strict sense, as rice milling has been brought under the ambit of rice bran oil industry, rational utilization of rice hulls will improve the economics of rice bran oil industry.

Hulls form about 25 percent of the paddy milled. It is estimated that 15 million tonnes of rice hulls will be available from 60 million tonnes of paddy milled in the country. It is chiefly used as cheap fuel, though it can be put to use in several applications as furnished below.:

1. In the manufacture of furfural, as it contains 11.4% of furfural.
2. It is used in the manufacture of cement as a cheap substitute to portland cement.
3. In the preparation of activated carbon.
4. Used as a raw material for refractory insulators.
5. In the manufacture of alkali silicates, silicone ash for glass industries.
6. Used in the production of industrial alcohol.
7. For abrasive coatings on travel belts.
8. In the manufacture of water resistent pressed boards.
9. In the manufacture of porous plates with rice hull ash.
10. For air conditioning units.
11. Used as an insulating material.
12. In the manufacture of particle boards and hard boards
13. Rice hull ash is used in the manufacture of dentifrices.

Utilization of by-products of edible rice bran oil industry.

S.No.	Name of the by-product	uses.
1.	Hulls	Furfural, cement, activated carbon, industrial alcohol particle and hard boards, alkali silicates, silicones, dentifrices, insulating materials, fuel etc.
2.	Deoiled bran	Cattle feeds, polutry feeds, fertilizers, source for Vitamins, sugars and starch
3.	Soap Stock.	Soap manufacture, fatty acids.
4.	Wax.	Polishes, stencils, carbon papers etc. Carnauba wax substitute.
5.	Spent earth	Recovery of industrial oil.

C H A P T E R VII

RESEARCH WORK ON RICE BRAN OIL IN INDIA.

Systematic research on rice bran and rice bran oil India was started in early fifties. Oil Technological Research Institute, Anantapur and Central Food Technolcgical Research Institute, Mysore are the two institutions where work on technological aspects were taken up. Adhoc research, especially of fundamental nature, was done for some time at Ferguson College, Poona. In mid fifties, Central Food Technological Research Institute, Mysore, did work on alcohol extraction of rice bran oil. Of late, they have been doing work on stabilization aspects of rice bran. In recent years some work has been done by Jadavpur University on stabilization (fluidized) of rice bran.

Research work on rice bran and oil formed one of the founding subjects of the work of the Oil Technological Research Institute, Anantapur production and utilization. It would be seen from the Institute's work as indicated in the abstracts later on in this chapter, that they have tried to find out solution to every type of technological problem and seen to have succeeded partly or wholly in their endeavours. Thirty two research papers and two patents published by them are a proof of this. Springs of scientific creativity are thinking and datum. While thinking can either be by intution or ratiocination, data require actual experience or long experimentation. As much of the ideas in the drafting of this project, a vade mecum of rice bran oil technology, are taken from the data of Oil Technological Research Institute, Anantapur, it is deered fit to give a bibliography (title, authors, journal reference and an abstract) of the research papers published by the Institute for ready reference and authentic documentation.

C.T.R.I. data

(1) A Review of work on Rice bran and Rice Bran Oil

K S Murti and G V Rao

Indian Oil seeds Journal, 1, No2

91-95 (January 1957)

Research work on production, refining and uses of rice bran wax is reviewed.

(2) Studies on the Indian Rice Bran and Rice Bran oil - 1

G V Rao, K S Murti and

K Chandrase Kharan

Indian Oil seeds Journal, 1 No.5

339-344 (October 1957)

Storage studies on a rice bran sample of local variety have been made at various intervals of time over a period of 100 days. The free fatty acids content of the oil which was 3 percent initially rose to 62.5 percent over a period of 100 days. The oil content remained constant. Moisture increased from 8.2 to 10.5 percent. Data on the* Andhra Pradesh are presented. Bran contains 5.6 to 12.5 percent of moisture, 12 to 20.5 percent oil, 3 to 78 percent FFA and 12.9 to 14.4 percent protein.

The rate of extraction of rice bran with different solvent has been studied at 82°F. at various intervals of time over an hour . It is found that alchol has a comparatively lower extraction rate and "Pegasol" has a higher extraction rate. Most of the oil will be extracted with in an hour by "Pegasol" and 3,3 P spirit leaving residual oil at one and two percent respectively.

A sample of rice bran oil was also refined using additives.

(3) A survey of the current Position of Rice Bran Oil and Bay in various countries.

* analysis of different varieties of rice bran (50 sample) produced in.

(6) Studies on Indian Rice Bran and Rice Bran Oil-II

J.S. kumar David,
D.Mrithyunjaya Rao,
S.D.Thirumala Rao and
K.S.Murti,
Indian Oilseeds Journal,
8, No. 1, 49 - 58(January1964)

The proximate composition of 59 samples of parboiled and raw rice bran is presented. The rice bran contains 3.78 to 11.32 percent moisture, 4.89 to 27.43 percent oil, 4.39 to 14.52 percent protein, 8.02 to 25.6% ash, 5.38 to 34.0 percent crude fibre and 1.8 to 8.9 percent FFA.

Characteristics of 39 samples of rice bran oil extracted with petroleum ether are determined. The limits are: Iodine value from 83.9 to 100.51; Saponification value from 120 to 127; wax content from 1.1 to 20.4 percent; and refractive index of the oil at 40°C from 1.455 to 1.470. Parboiled rice bran possesses higher oil content than raw bran. Other characteristics like chlorophyll and squalene contents are also determined for selected oils.

(7) Studies on Indian Rice Bran and Rice Bran Oil-III purification and bleaching of Crude wax.

K.Venkateswara Rao and
S.D.Thirumala Rao,
The Indian Oil and Soap Journal
29, No. 7, 177-180 (january,1964)

From "Crude Wax" containing over 50 percent of the wax, hard non tacky ashless wax is separated and bleached to whiteness by means of chromium trioxid and sulphuric acid. "Crude wax" contains 16.5 to 25.2 percent oil, 51.8 to 52.5 percent true wax and 22.3 to 31.7 percent nonlipids. Characteristics of true wax are:

Saponification value 86.4 to 87.2; Iodine value 7.0 to 10.0; FFA 2.1 to 6.5; non-saponifiable matter 44.5 to 56.1 percent ash content 0.05 to 0.3 percent and melting point 81 to 82°C.

(8) Rice Bran Oil, its Extraction and Utilization.

S.D.Thirumala Rao

Presented at the ThirdConference of Oilseeds Research Workers in India, held at Bhopal, India on 13th to 15th April, 1964

A review on extraction and utilization of rice bran is made. The rice bran extraction plants and their performance in India, storage of rice bran, extraction of rice bran (mechanical hydraulic pressing and solvent extraction), materials for construction of the extraction plants, utilization of rice bran oil, sieve analysis of huller bran and sheller bran, characteristics and specifications of rice bran oil are discussed in detail. Phosphatide and oryzanol contents and fatty acid composition of rice bran oil are given.

Deacidification, distillation, alkali-refining, steam-refining, molecular distillation, estrification, hydrogenation and splitting of rice bran oil are also discussed. Fifty references and 20 Tables.

(9) Improved Process forBleaching Crude Rice Bran Oil

K.Venkateswara Rao,
B.Panduranga Rao,
B.A.R. Somayajula, R.Mohan
and S.D.Thirumala Rao.

Indian Patent No. 98 403,
March 11, 1965

This is a process for bleaching crude rice bran oil to yi ld a light-coloured oil involving treatment with aliphatic dicarboxylic acids and polyhydroxy aliphatic acids.

(10) Oil-Based Surface -Active Agents III. Sulphation of Oils and Co-Sulphation of Misture of Oils.

D.Atchyuta Ramayya, M.A. Sampath Kumaran, S.D.Thirumala Rao and K.S.Murti. Indian Oilseeds Journal, 9, No.3, 161-167 (July-September 1965).

Sulfation of rice bran oil is done with concentrated sulphuric acid or with chlorosulfonic acid or with fuming sulfuric acid. The sulfated product is evaluated for wetting, emulsification, forming and calcium soap-dispersion. Incorporation of castor oil to the extent of 20 to 25 percent into rice bran oil yields sulfated product of satisfactory properties.

(11) Quality of Bran Oil as Influenced by the Conditions of Storage of rice bran.

J.S.Kumar David, S.Kutumba Pao S.D. Thirumala Rao Rao and K.S.Murti. Journal of Food Science and Technology, 2,No. 3-4, 113.114 (October-December 1965)

The storage behaviour of rice bran with respect to the quality of oil extracted from it has been studied over a period of 30 days at room and low temperatur . The studies have shown that the rise of FFA in the extracted oil after six hours of storage of br n from the time of its production is nearly double the initial value. The F.F.A. rises to 40 percent

after 30 days of storage. At lower temperatures of 3.3 t 12.8°C rice bran keeps well and even after 30 days of storage, the maximum rise in FFA is only 13 percent.

(12) Studies on the Indian Rice Bran and Rice Bran Oil V Hydraulic Pressing of Rice Bran.

S.D.Thirumala Rao, D.Mrithyunjaya Rao and K.S.Murti, OTA Bulletin, Calcutta Annual Number, 49-5((December 1965)

Experiments on the hydraulic-pressing of rice bran are conducted and the optimum conditions are found to be as follows:

(i) Moisture level in the bran, 7-12 percent

(ii) Temperature, 100 ± 2°C

(iii) Pressure, 78-5000 P.S.I (tried with about equal effect).

(iv) Time of pressing adopted in the work is one hour.

Oil yields between seven to ten percent are obtained from the brans with 17 to 19 percent oil 13 to 15 percent from bran with 27.4 percent oil and 12 to 14 percent from bran with 26.9 percent oil. Pressure does not have any decisive eff on the yields of oil from brans though brans with very hig oil contents give slightly higher oil yields at high r pressures.

(13) Molecular Distillation-Part IV Rice Bran and Groundnut Oils.

K.Viswanathan, M.R.Surendranath G.Azeemoddin and S.D.Trirumala Rao. Chemical Age of India, 16, No. 12,1012-1035 (December 1965)

The characteristics of different fractions of rice bran oil and groundnut oil obtained at high vacuum are reported. Nine to 25 percent of purefatty acids are distilled below 200°C. The sample of rice bran oil having 12 percent FFA yields 76 percent of light-coloured and odourless oil with about one percent FFA, while the other having 28 percent FFa yields 53 percent of the light-coloured and odourless fraction with about two percent FFA.

(14) Oil-Based Surface-Active Agents-IV-Sulphation of Monoglyerides.

D. Atchyta Ramayya,
Y.Girish Chandra Kumar and
S.D.Thirumala Rao
The Indian Oil and Soap Journal, 31
No. 12, 335-340 (June 1966)

Monoglyceride-rich rice bran oil (48% monoglyceride content) gives uniformly better products with concentrated sulfuric acid. Strong sulfating agents like oleum and chlorosulfonic acid do not give as good products as those with sulfuric acid.

(15) Wax and Fatty Acids from Rice Bran Oil Sludges

K.Venkateswara Rao,
B.Panduranga Rao, G.Siva Rami Reddy, B.A.R.Somayajulu and
S.D.Thirumala Rao.
Fette-Seifen-Anstrichmittal,
58,No-9 746-48 (September 1966)

Sludges obtained as tank-settlings from solvent-extracted bran oil have been shown to be rich sources of wax and fatty acids. The wax content is variable being about 18 percent in one sample and about 39 percent in a second sample of sludge. The wax is bleached to light colour.

The crude shows good compatibility with other types of waxes. The oil fraction of sludges is high in free fatty acids (over 70 percent) about three fourth of which could be vacuum-distilled directly to yield light-coloured fatty acids.

(16) Rice Bran Agro-industrial Raw Material.

S.D.Thirumala Rao
Andhra Pradesh Industries Bulletin, 1 No 5,34.39, 45
(October 1966)

Statistical data of production of rice bran, hullers statewise in India are given, the relative compositional features of huller and sheller bran are as follows: Moisture, 9 and 10 percent, oil 8 and 18 percent protein 8 and 12 percent, sand and silica 13 and 8 percent and crude fibre 17 and 9 percent respectively. Uses of rice bran are stressed. The extracted bran meal constitutes better cattle-feed and fertilizer as it is richer in nitrogen phosphorous, vitamins etc. than the original bran. The settling of crude rice bran oil contains about 75 percent fatty acids, 15-20 percent wax and two to three percent grits. Methods to separate wax and fatty acids from the settlings are developed. The rice hulls are used in the manufacture of furfural, synthetic fibre, plastics, activated carbon, sugars, alcohols, card boards etc. A brief reference to the research work done on rice bran in the Institute, research papers published by the Institute, technical inquiries on various aspects prepared etc. is made. Recommendations of the adhoc Committee on Rice Bran Oil Industry appointed by the Government of India in 1959-60 are documented.

(17) Factors Affecting the Free Fatty Acids changes in Rice Bran,

B.Pandurangа Rao, S.Ansar Ahmed and S.D.Thirumala Rao,
The Indian Oil and Soap Journal, 203-210 (January 1967) 32, No.7

Various factors likely to influence the rise of free fatty acid contents in rice bran on storage are investigated. The factors are, effect of (i) addition of extraneous moisture to the original bran as well as to the heated bran, (ii) drying, (iii) humidification, cooling and drying, (iv) relative humidities, (v) dehydrating agents, (vi) addition of alkali halides and (vii) particle size. Heating the original bran and bringing down its moisture content below two percent whould stabilise the bran. The fine particle size of rice bran in which oil is exposed over alarge surface appears to be primarily responsible for the rapid rise of free fatty acid in the bran on storage. A hypothesis that "the lipolytic activity in rice bran is not more than in sesame, groundnut and other oleaginous materials reduced to the similar fine particle size as rice bran" is propounded based on experimental data.

(18) Oil Based Surface-Active Agents-V. Composition and Gross Properties of Soap from Some Non-Edible Oils.

C.Ramaprasad, B.A.R.Somayajulu and S.D.Thirumala Rao

OTA Bulletin(Calcutta) 11-13 (January-March 1967)

Soap prepared from rice bran oil has good properties and characteristics which can be compared with those of coconut oil soap. The characteristics studied are moisture, total fatty matter, glycerol content, free and combined alkali of the soap. The properties studied are titre test, foaming, wetting and detergency.

(19) Indigenous Substitutes of Palm Oil in Tinplate Process.

K.Venkateswara Rao, G.Sivarami Reddy, B.Panduranga Rao, B A R. Somayajulu and S.D.Thirumala Rao

Indian Food Packer,28, No,1 1-4 (1967)

Work on indigenous substitutes for palm oil in tin plate process is presented. Crude rice bran oil has got approximate qualities. It (a) drains quickly and freely from the tin sheet and makes smooth bright tin plate, (b) has high flash and fire points and low volatility, (c) is free from bad odour and toxicity, (d) does not undergo polymerization readily, (e) possesses low viscosity, (f) resists atmospheric corrosion and (g) is readily available and is not more expensive than palm oil.

(20) An Improved Process for Bleaching Raw Rice Bran Oil (In German)

K.Venkateswara Rao, B.Panduranga Rao, R.Mohan, B A R Somayajulu and S.D.Thirumala Rao
Seifen-Ole- Fette-Waches,93
No. 26, 970-972 (December 20,1967)

A method of obtaining light yellow-coloured oils from raw rice bran oils of dark brown or green colour has been evolved. This consists of pretreatment of oil with one to five percent of aliphatic dobasic acid like oxalic or polybasic hydroxy acids like tartaric, citric or malic acids followed by bleaching with two to four percent of bleaching earth and 0.2 to 0.4 percent of activated carbon.

(21) Oi-based Surface-Active Agents-vii. Sulphation or Fatty Acids, Oils in Diluents and Fatty Acid Esters.

D.Atchyuta Ramayya, M.A. Samptah Kumaran, C.Chandrasekharan Kartha, S.D.Thirumala Rao and K.S,Murti.
Indian Chemical Manufacturer,6
No. 7, 7-12 (July 1968)

Fatty acids of rice bran oil amorg others are sulfated on Laboratory scale, Sulfation of rice bran oil and rice bran oil mixed with fatty acids is done. Sulfated products of mixed fatty acids of rice bran oil possess satisfactory properties.

(22) Studies on Indian Rice Bran and Rice Bran Oil-x. Refining of Distillation Residue.

K.Venkateswara Rao, B.Panduranga Rao, G.Sivarami Reddy and S.D.Thirumala Rao. OTA Bulletin (Calcutta), Annual Number, 65-67 (December 1968)

Alkali-refining of residual oil, obtained after distilling excess free fatty acids from high-acid solvent-extracted rice bran oil gives incommensurably high refining losses of 21 to 50 percent inspite of its low FFA (about two percent.) Use of two percent molasses as additive prior to or during alkali treatment stage, reduces the refining losses of the same oil by 10 to 14 percent.

(23) Improvements in or Relative to Bleaching of Rice Bran Wax.

B.Panduranga Rao, G.Sivarami Reddy and S.D.Thirumala Rao Indian Patent No.119 747, February 7, 1969.

Process consists in agitating crude wax in molton condition with nitric acid, removing the spent mineral acid, drying the bleached wax by melting and decanting th wax.

(24) Rice Bran Milling

D.Ramachar,R.K.Vishwanatham and S.D.Thirumala Rao. The Oils and Oilseeds Journal, 21,No 10 13-14 (April 1969)

Technical feasibility of milling rice bran in an expeller has been explored, Mixing of rice bran (18 percent oil content) with an equal quantity of first-pressed groundnut cake (15 percent oil content) and special cooking conditions gives not rice bran oil yield upto six percent on the weight of rice bran crushed. On refining and bleaching with activated earth and carbon the resulting rice bran oil becomes light yellow. The second-pressed cake from the mixture of rice bran and groundnut cake has about 30 percent protein content and has good texture and roasted appetizing flavour.

(25) Rapid Field Methods of Analysis of Rice Bran

A.Gautama, G.Sivarami Reddy B.Pandurangа Rao and S.D. Thirumala Rao Journal of the Oil Technologists' Association of India 2 No 1 23-24 (January-June1970)

Rapid methods of analysis, adaptable on the sport, are described. To a known weight of rice bran (2g) about 20 ml. of n-hexane is added, stirred and allowed to settle for 3 minutes. The clear supernatant miscella is decanted. The operation is repeated thrice to recover all oil. The difference of weight between original rice bran and deoiled bran is taken as the oil content. This experiment takes only 15 minutes and the results agree well with the standard method. To the pooled miscella, neutral alcohol and phenolphthalein are added and titrated against standard alkali in cold and FFA calculated as usual.

To determine the sand and free silica content, to a known weight of rice bran 20-30 ml. of carbon tetrachloride. is added, stirred and allowed to settle, when sand, silica, etc., sink and the bran floats.

Carbon tetrachloride is decanted and the floating bran scooped out. After repeating with fresh carbon tetrachloride till all the vegetable matter is removed, the remaining sand and silica are dried, weighed and their contents calculated. This method takes only 15 minutes as against 4 hours by standard "Insoluble ash" method.

(26) An Improved Method of Bleaching of Rice Bran wax.
B.Pandurangа Rao, G. Sivarami Reddy and S.D. Thirumala Rao.
The Journal of the Oil Technologists' Association Of India, 2, No 2. 132-33 (July.December 1970)

An improved method of bleaching dark-coloured crude rice bran was with a brany odour and m.p. 75-76°C to orange-coloured product, m.p.79°C and substantially free from odour has been developed.

The method consists in agatating crude wax in molten state with equal quantity of 50 percent nitric acid for one to two hours, washing the bleached wax, melting and decanting the supernatant molten wax to eliminate non-waxy solid material.

(27). Effect of Refining and Bleaching on the Unsaponifiable Matter of Rice Bran Oil
B.Pandurangа Rao, S.D.Thirumala Rao, and B.R. Reddy.
The Journal of Oil Technologists' Association of India, 3, No.1 10 & 20 (January June 1971)

Raw rice bran oil contains high unsaponificab matter varying from 4.2 to 6.6 percent. Reducing the unsaponifibales to an acceptable level is one of the main problems of the industry towards putting rice bran oil as an edible product in the market. The effect of processing on 12 samples shows that the unsaponifiable matter contents of crude oil vary from 4.2 to 6.6 percent with an average of 4.9 percent and those of refined and bleached oils vary from 2.0 to 5.0 percent with an average of 3.5 percent. The percentage reduction of unsaponifiable matter vary from 25 to 26 percent with an average of 28 percent.

(28) Rapid Methods for Determination of Free Fatty Acids Contents in Fatty Oils

B.Panduranga Rao, S.D. Thirumala Rao and B R Reddy
The Journal of the America Oil Chemist Society. 49, No, 5, 338-339 (May 1972)

Rapid qualitative and quantitative methods for determining the free fatty acid (FFA) contents in common oils and fats are reported. Qualitative method is based on the type of colour developed in the presence of BDH indicators (universal and "678") when known excess of alkali as added to an alcoholic solution of oil or fat. By this method, low (0.0 to, 0.25), medium (0.26 to 0.99) and high (1.0 and above) FFA levels in fatty oils may be distinguished Quantitative method is a simplified modification of the usual procedure of determining the FFA contents of oils and fats by titration against standard alkali solution in the presence of BDH universal or "678" indicator. The results of the rapid methods agree well with those of the standard ACCS methods.

(29) Rice and Wheat Germ Oils

B.Panduranga Rao, A.Gautama, G.Siva Rami Reddy and S.D. Thirumala Rao,
The Journal of Oil Technologists' Association of India 4 No.2 87-88 (July-September 1972)

The yields of rice and wheat germs are about 0.5 to one percent on the weight of grain milled. Composition of mill-produced rice and wheat germs and characteristics of extracted oils therefrom are described.

Storage studies of rice and wheat germs are conducted. The increase in FFA in both wheat germs and rice germs is of the same order. The FFA reached a level of 12 percent in about 28 days. The germs should be heat-stabilized soon after production in mills if the germs are intended for either extraction of edible oil or to be used as constituent in breakfast snack foods.

(30) A Modified Acetic Anhydride-Sulphuric Acid Colour Test for Oils.

G.Azeemoddin, S.D.Thirumala Rao and B.R.Reddy.
The Journal of the American Oil Chemists' Society, 50, No. 12, 545-546 (December 1973)

A characteristic colour test involving modified acetic anhydride-sulphuric acid reagent has been developed for rice bran oil. The test is performed at ambient temperature as follows: dissolve 0.2 ml rice bran oil (or 5 drops) in 2 ml chloroform and add 5 ml acetic anhydride. Shake well and add one or two drops of sulphuric acid. It develops a colour sequency of brown-green-bright green.

The test provides a semi quantitative basis to detect the presence of rice bran oil in mixture with either constlier oils like groundnut oil which is usually the target in Indian market for admixture with cheaper edible and non-edible oils.

The test has also wider applicability to other oils

(31) Removal of Sand and Silica from Rice Bran

G.Sivarami Reddy, B.Panduranga Rao, G.Azeemoddin, R.K.Viswamtham, S.D.Thirumala Rao and B.R.Reddy.
The Journal of Oil Technologists' Association of India,6,No.3
(July-September 1974)

Air classification, differential settling and sieving methods are applied to remove freesand and silica from rice bran. Rice bran contains varying amounts of sand and silica in free and bound forms. And storage practices of paddy and the mixture of sand and silica into rice bran by design or accident at various point of its production, distribution and marketing. Rice hulls contain bound silica to the extent of 20 percent and rice bran from huller process in which hulling and polishing are accomplished in one step contains all the rice hulls and therefore considerable silica in bound form. Sheller process with quality control and adopting standards for the rice bra and avoiding hulling process will result in rice bran with low permissible levels of sand and silica. But in the existing conditions, rice bran of diverse and indifferent quality is being produced. Benefication methods are, therefore, tried based on different principles mentioned in the beginning.

(32) A Stabilizer for Rice Bran

G.Sivarami Reddy, R.K.Viswanadham, S.D.Thirumala Rao and B.R.Reddy

Paper read at the Symposium of OTA of India held at Hydrabad in February 1974 and also read at the Seminar on Modernisation of Rice Milling held on September 22, 1974 at Calcutta under the joint auspices of East India Rice Mills Association Calcutta and Ministry of Food and Agriculture, Government of India.

An experimental rice bran stabilizer (8-16 kg per hour capacity) set up in which rice bran is continuously conveyed forward by a screw in a flue gas heated-tube is described. Flue gases are generated by burning agricultural wastes or any solid fuel.

CHAPTER VIII

SUMMERY AND CONCLUSIONS

The rice bran oil industry is in existence in Japan, USA, Chile, Burma and India. At present, it is flourishing in Japan and India.

In India, rice bran extraction for oil came into being in early sixties. India produces 3.5 million tonnes of rice bran with an oil potential of over half a million tonnes but in 1974 about 65,000 Tonnes of rice bran oil are reported to be produced. All the oil produced is only fit for soap making.

About 30 plants regularly extract rice bran.

The export of rice bran to countries like Hungary, Czechoslavakia, Poland has increased from Rs 1.20 crores in 1967-68 to Rs 3.57 crores in 1973-74.

The quality of bran produced in the rice milling industry is a vital factor for the rice bran oil industry. Hullers, shellers and modern rice mills are three methods of milling paddy. Hullers and bran is low in oil and protein contents, high in ash and crude fibre. Bran from shellers and modern rice mills is high in oil and protein and low in ash and crude fibre contents. Parboiling is practised in some states. Scientifically parboiled bran yields better quality oil than raw bran.

Huller mills are to be converted into shellers by giving suitable incentive and directives. Rubber cone polishers are also used by rice mills.

Rice bran oil is green in colour, contains wax and has a peculiar odour and high acidity. These defects have to be removed to make it fit for edible purposes.

Edible rice bran oil production is problem-ridden. The rapid rise of free fatty acid content in the bran is the biggest hurdle. The lipolytic activity in rice bran has verily been the will-o'- the wisp of edible rice bran oil technology.

Rice bran shoud be extracted immediately after its production to yield low acid oil. Where it is not possible, rice bran should be "Stabilized" either with cold or heat-treatment. Heat-treatment is more economical. There are a number of stabilization techniques available on the experimental level. No method is used commercially as on to-day.

Production of edible rice bran oil consists of extraction of bran, dewaxing, alkali-treatment, bleaching and deodourization of oil.

Two categories of schemes are recommended - one for processing 15 tonnes or rice bran per day producing edible rice bran oil. This involves a capital investment for Rs 35.67 lakhs with a profit of 36 percent. This type of unit could be set up in areas where rice mills are situated within a radius of 100 km.

A string of this type of plants should be set-up along the costal line in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kuttanad area (Kerala) and going up to north Canara coast upto Goa, Centres in Assam, Madhya Pradesh, Maharashtra, Punjab, Haryana and Bihar may also be selected for their location. If 150 exclusive units (with a total investment of Rs54 crores) are set up about 1 lakh tonnes of edible rice bran oil valued at Rs 80 crores could be produced annually in India.

Second type of scheme is for extracting 2 tonnes of fresh bran per day producing low-acid refinable oil. The tiny plant involves a capital investment of Rs 5.83 lakhs and yields a profit of over 20 percent. These types of plants can be set-up in every town in delta area of Andhra Pradesh in which fresh sheller rice bran upto 3-4 tonnes would be available daily.

Rice bran meal, soap stock, wax and spent earth are bye products of edible rice bran oil industry. Deoiled meal rich in carbohydrates and proteins forms a good cattle feed supplement. Rice bran wax after bleaching will be a partial substitute for the imported carnauba wax.

Technology is a result of research. Creativity is a product of thinking and data. Research, thus forms the nucleus of all technological development. Research on rice bran and its oil is going on in India and should be encouraged. Research work done in various laboratories in India has been reviewed. Work at the Oil Technological Research Institute, Anantapur has been bibliographed.

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